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MYCOTAXON

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Volume LXXXIV October-December 2002

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LA POSITION SYSTÉMATIQUE DE POLYBLASTIA DEMINUTA

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Résumé

Polyblastia deminuta n'est pas un lichen, mais un champignon lichénicole non lichénisé, s'établissant sur des lichens à thalle endolithique en mauvais état, mourants ou même morts (diverses Verrucariaceae et peut-être d'autres lichens à thalle endolithique indéterminés). Il appartient au genre *Merismatium* (Verrucariales, Verrucariaceae), ce qui rend nécessaire la nouvelle combinaison *Merismatium deminutum*. Certains spécimens orophiles (étage subalpin supérieur et étage alpin) diffèrent suffisamment du type (étage supraméditerranéen et surtout montagnard) pour justifier la description de la nouvelle sous-espèce *Merismatium deminutum* subsp. *longisporum*.

Abstract

Polyblastia deminuta is not a lichen, but a lichenicolous, non-lichenized fungus. It grows on the poorly developed or dying, endolithic thallus of several lichens (mainly species of Verrucariaceae, and possibly other unidentified species with an endolithic thallus). *P. deminuta* should be included in the genus *Merismatium* (Verrucariales, Verrucariaceae) as *M. deminutum*. Some of the more orophilous specimens of this fungus (alpine and superior sub-alpine belts) sufficiently differ from the typical specimens (mainly mountain, also supra-Mediterranean) by the spore shape, septation and size. This justifies the description of a new subspecies: *Merismatium deminutum* subsp. *longisporum*.

Resumo

Polyblastia deminuta ne estas likeno, sed nelikeniĝinta fungo nelikenloĝa, kreskanta en likenoj kun enpetra talo, malbone stataj, mortantaj aŭ eĉ mortintaj (diversaj Verrucariacea kaj eble aliaj nedeterminataj likenoj kun talo enpetra). Ĝi apartenas al la genro *Merismatium* (Verrucariales, Verrucariaceae), kio necesigas la novan kombinaĵon *Merismatium deminutum.* Iuj altmontaj specimenoj (supra subalpa kaj alpa etaĝoj) sufiĉe diferencas de la tipo (suprameditaranea kaj precipe monta etaĝoj), por pravigi la priskribon de la nova subspecio *Merismatium deminutum* subsp. *longisporum.*

Introduction

Polyblastia deminuta Arnold est une espèce d'ascomycète assez commune dans les montagnes calcaires, jusqu'ici considérée comme un lichen saxicole et traitée comme telle dans les flores usuelles, notamment de Clauzade et Roux (1985), Ozenda et Clauzade (1970), Purvis *et al.* (1992). Toutefois Clauzade et Roux (1985 : 614) précisent qu'elle n'appartient vraisemblablement pas au genre *Polyblastia* par ses spores halonées, et Clauzade *et al.* (1989 : 75) la considèrent comme lichénicole vraisemblablement non lichénisée (sur diverses espèces de lichens), tout comme l'espèce voisine *Polyblastia discrepans* Lahm (sur *Protoblastenia, Hymenelia, Aspicilia*).

Triebel (1989) place *Polyblastia discrepans* dans le genre *Merismatium* Zopf, qui comprend uniquement des espèces lichénicoles soit non lichénisées soit de lichénisation douteuse ou facultative (associées à des goniocystes). En raison des grandes affinités entre *Polyblastia deminuta* et *Merismatium discrepans* (Lahm) Triebel et du caractère vraisemblablement non lichénisé de ce premier, deux d'entre nous (C. R. et P. N.-R.) ont réexaminé, il y a déjà une dizaine d'années, leur matériel de *Polyblastia deminuta* pour arriver à la conclusion que cette espèce était bien un champignon lichénicole non lichénisé s'établissant sur des thalles en mauvais état, mourants ou même morts de diverses Verrucariaceae à thalle endolithique. Bien que la combinaison provisoire *Merismatium deminutum* (Arnold) ait été utilisée en quelques occasions par l'un d'entre nous (Navarro-Rosinés 1992, Navarro-Rosinés *et al.* 1994), ce n'est que tout récemment que nous avons examiné les spécimens originaux d'Arnold de *Polyblastia deminuta* (M) pour nous assurer de l'identité du matériel étudié antérieurement.

Matériel et méthodes

Les coupes et préparations microscopiques ont été réalisées à main levée et observées dans l'eau, le lugol (I), une solution aqueuse d'hydroxyde de potassium à 10 % (K), le bleu de crésyl (BCr) et le bleu au lactophénol (bleu coton dans le lactophénol), avec un microscope photonique (grandissement maximal de × 1500) muni d'un dispositif de contraste interférentiel. Les dessins ont été réalisés avec l'aide d'un tube à dessin.

Dans la mesure du possible, du matériel frais a été observé, mais comme une partie des spécimens étudiés sont anciens, les mesures, pour être comparables, ont été effectuées dans l'eau, sur du matériel mort. Dans l'expression des dimensions des spores (halo non compris) la moyenne est indiquée en italique, encadrée par les valeurs extrêmes après élimination des 10 % des valeurs les plus élevées et des 10 % des valeurs les plus faibles, tandis que les valeurs extrêmes absolues sont placées entre parenthèses.

Merismatium deminutum (Arnold) Cl. Roux et Nav.-Ros. comb. nov.

Bas. *Polyblastia deminuta* Arnold, *Flora*, **44**: 264 (1861).
Type: An einem Dolomitfelsen des sonnigen Abhanges am Wintershofer Berge bei Eichstätt (968!). M, holotype.

Ascomes (fig. 1) périthécioïdes, du type pseudothèce, noirs, enfoncés dans le thalle de diverses Verrucariaceae à thalle endolithique en mauvais état, mourantes ou même mortes (notamment de *Verrucaria, Thelidium, Polyblastia*) et peut-être d'autres genres de lichens à thalle endolithique (le plus souvent l'hôte n'est pas déterminable), oblongs, ellipsoïdaux ou ovoïdes, à la fin souvent en partie saillants (jusqu'au 1/3), de 0,15–0,3 mm de diamètre et 0,2–0,35 mm de hauteur, à ostiole plus ou moins visible, parfois sous forme d'une dépression ou même d'un orifice apical.

Paroi ascomale (excipulum) en grande partie brun sombre et épaisse (35–50 µm) dans la moitié supérieure, plus particulièrement au sommet de l'ascome, en grande partie brun pâle et plus mince (20–25 µm) dans la moitié inférieure, entièrement paraplectenchymateuse (= pseudoparenchymateuse), formée de deux parties:

– Partie externe pigmentée de brun, de 15–40 µm d'épaisseur, plus épaisse dans la moitié supérieure (20–40 µm d'épaisseur, formée de 8 à 12 couches de cellules), plus mince à la base (13–20 µm d'épaisseur, 4 à 6 couches de cellules). Cette partie externe est constituée de cellules plus ou moins anguleuses, formant sur une coupe verticale tangentielle une *textura angularis* plus ou moins visible (lumière des cellules de 3–6,5 × 2–5,5 µm), alors qu'elles sont allongées sur une coupe verticale axiale [lumière de (3)5–10 × 1,5–4 µm]. Les cellules situées au voisinage de l'ostiole sont nettement plus allongées (lumière de 8–24 ×

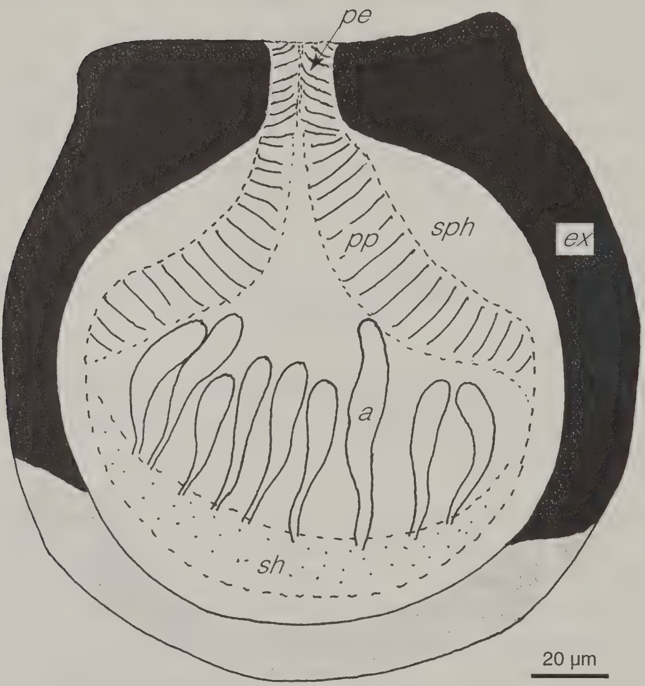

Fig. 1. Structure microscopique d'un ascome mûr de *Merismatium deminutum,* d'après une coupe verticale passant par l'ostiole, observée dans le bleu au lactophénol (M, Tyrol autrichien) ; semi-schématique. *a*: asques issus du subhyménium ; *ex*: excipulum ; *pe*: périphyses (au-dessus, de la formation externe ; au-dessous, de la formation interne) situées dans le court canal ostiolaire ; *pp*: pseudoparaphyses courtes, du type b, issues du suprahyménium, situées dans la moitié supérieure de la cavité ascomale, sous le canal ostiolaire et au-dessus des asques ; *sh*: subhyménium ; *sph*: suprahyménium.

1,5–3 µm sur une coupe verticale axiale). Toutes ces cellules ont leur paroi interrompue çà et là par des pores de Munk.

– Partie interne incolore, de 5–15 µm d'épaisseur, à cellules plus ou moins arrondies (à lumière de 5–11 × 5–10 µm sur une coupe verticale axiale), formée de une à six couches de cellules, se prolongeant vers le haut par le suprahyménium (voir plus loin).

La paroi ascomale est assez souvent entourée d'une couche externe incolore assez irrégulière, formée de quelques strates de cellules incolores à paroi relativement épaisse (1,5–2 µm), rondes (lumière de 1,5–3 µm de diamètre) ou allongées (lumière de 4–8 × 1–3 µm), formant de courts filaments reconnaissables (structure plus moins distinctement prosoplectenchymateuse). Ces hyphes appartiennent soit à *Merismatium deminutum* et doivent donc être alors considérés comme des hyphes végétatives formant une sorte de manchon inégal autour de l'ascome, soit beaucoup plus vraisemblablement au thalle de l'hôte.

Subhyménium (25–35 µm d'épaisseur), limité à environ la moitié inférieure de l'ascome, formé de quelques couches de cellules ascogènes associées de façon lâche.

Suprahyménium prolongeant vers le haut la partie interne incolore de l'excipulum, formé de plusieurs couches de cellules arrondies (lumière de 2–5 µm de diamètre) et assez lâches, à l'origine des pseudoparaphyses courtes (voir ci-après) et des périphyses.

Hyménium : gelée hyméniale et l'épiplasme I+ de jaune orangé à rouge orangé (réaction hémiamyloïde), KI+ (bleu).

Hamathécium formé de périphyses (fig. 2) et de pseudoparaphyses courtes (fig. 3 et 4), issues du suprahyménium, les périphyses de la partie la plus supérieure du suprahyménium.

Périphyses localisées à la partie la plus supérieure des ascomes, dans le court canal ostiolaire, allongées et minces (12–21 × 1,5–2 µm), simples et formées de 2–3(4) cellules, ou peu ramifiées, légèrement renflées à l'apex (jusqu'à 3 µm d'épaisseur), les plus externes (périphyses de la formation externe) à cellule apicale pigmentée de brun, les internes (périphyses de la formation interne) semblables, mais entièrement incolores. Les périphyses, sont visibles sur une coupe longitudinale seulement si elle passe par l'ostiole, mais on les observe plus aisément sur une calotte supérieure d'ascome modérément écrasée.

Pseudoparaphyses courtes (= périphysoïdes) du type b (ROUX et TRIEBEL, 1994), situées immédiatement au–dessous des périphyses (et du canal ostiolaire), de 12–34 × 2–5 µm, la plupart simples et formées de (2)3–4 cellules, parfois fourchues ou anastomosées, nettement plus larges que les périphyses, à cellule de base peu ou pas distincte de celles du suprahyménium. Bien que ces pseudoparaphyses courtes soient nettement distinctes des périphyses par leur morphologie et leur

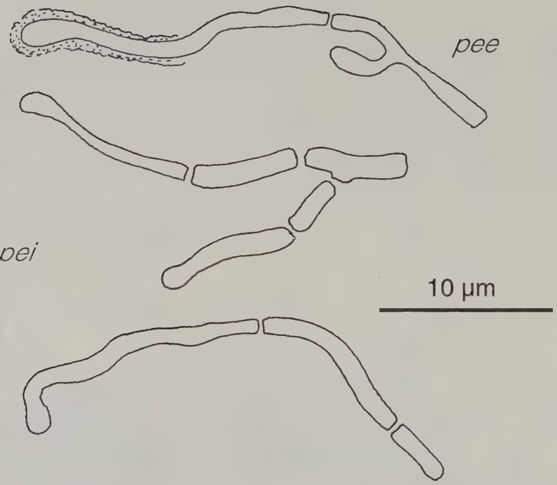

Fig. 2. Périphyses de *Merismatium deminutum,* observées dans le bleu au lactophénol (*pee*: de la formation externe; *pei*: de la formation interne). M, Arnold, Eichstätt, 1861 (topotype).

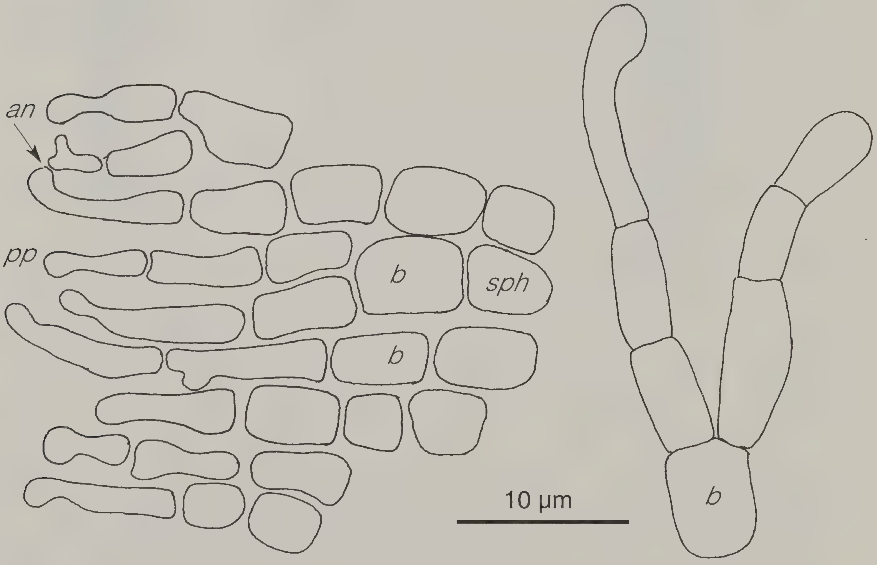

Fig. 3. Pseudoparaphyses courtes de *Merismatium deminutum* observées dans le bleu au lactophénol; *an*: anastomose; *b*: cellule de base; *pp*: pseudoparaphyse; *sph*: cellules du suprahyménium. M, Arnold, Eichstätt, 1861 (topotype).

Fig. 4. Pseudoparaphyse courte de *Merismatium deminutum* subsp. *longisporum,* ramifiée, observée dans l'eau (holotype). *b*: cellule de base.

position spatiale, elles n'ont pas été distinguées des périphyses par SWINSCOW (1971). Par contre TRIEBEL (1989), dans la description du genre *Merismatium*, mentionne la présence de périphysoïdes outre celle de périphyses.

Asques (fig. 5) claviformes, de 67–92 × 17–31 µm, courtement ou très courtement pédonculés, contenant 8 spores disposées irrégulièrement ou sur deux rangs dans les asques, bituniqués, à paroi assez épaisse mais peu notablement épaissie dans la partie supérieure, à chambre oculaire petite mais bien visible sur le matériel frais et même sur le matériel d'herbier après montage dans le bleu au lactophénol, montrant parfois une nasse apicale. Pas de réaction métachromatique avec le bleu de crésyl (seul l'épiplasme se teinte en bleu). REMARQUE : Sur quelques spécimens de ARNOLD (M), on observe dans plusieurs asques, outre les 8 spores normales, 1 à 3 petites cellules globuleuses, non halonées et restant incolores, dont l'origine est inexpliquée.

Déhiscence se produisant par rupture non brutale, le long d'une ligne circulaire, au sommet de l'asque par lequel fait saillie l'endoascus ; la rupture semble se produire après gélification du sommet de l'exoascus puisque l'on n'observe ni clapet latéral ni sommet d'exoascus à proximité des asques déhiscents, ce qui correspond au mode général de déhiscence des Verrucariaceae.

Ascospores (fig. 6) ellipsoïdales, plus rarement ovoïdes, au tout début incolores et simples, uni- ou tri-septées, puis devenant gris brun pâle et submurales, à maturité d'un gris brun plus ou moins sombre, submurales ou faiblement murales, de (18)20–*24,0*–27,5(31) × (10)11–*13,0*– 15(17) µm, à rapport longueur sur largeur de (1,5)1,6–*1,9*–2,0(2,4), à 3– 4(5) cloisons transversales et (1)3–6(8) cloisons longitudinales (statistique établie d'après la mesure de 75 spores mûres), entourées d'une périspore épaisse formant un halo très distinct de (1)2–3(4) µm d'épaisseur.

Conidiomes inconnus.

Hyphes végétatives issues de la base des ascomes, incolores (sauf tout à fait à la base où elles sont parfois brunes), à paroi de 1–1,5 µm et à lumière de 3–8 × 1–3 µm. Voir aussi plus haut, Ascome, Paroi ascomale.

Variabilité

La description des spores qui précède vaut pour les spécimens typiques, ayant leur optimum aux étages subméditerranéen et surtout montagnard, plus rarement, dans les Pyrénées orientales (val de Núria), à l'étage subalpin.

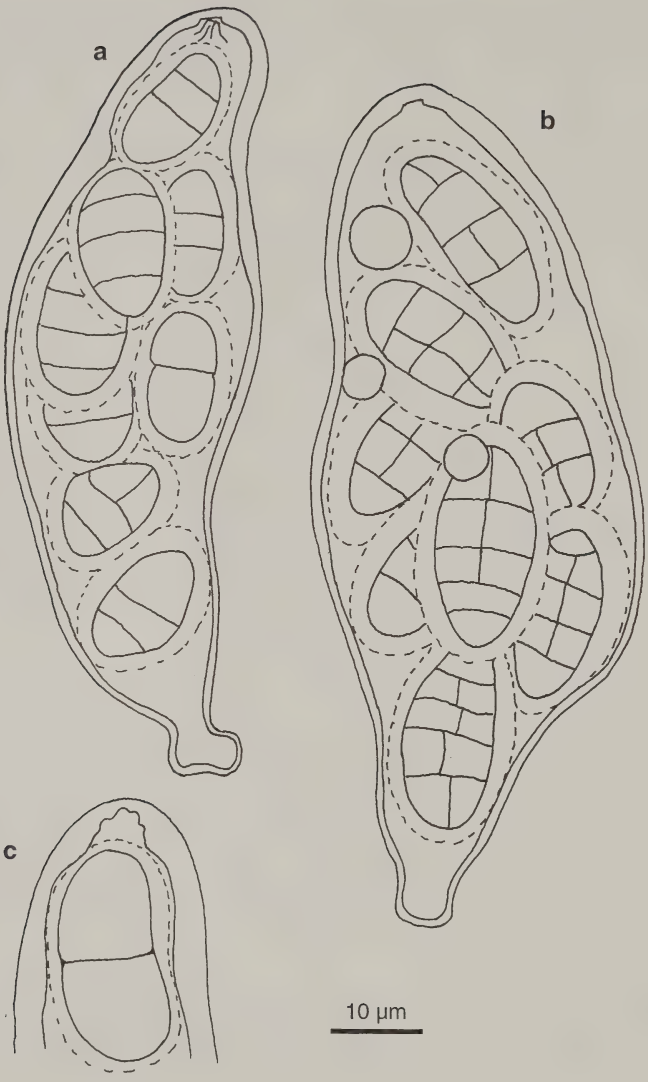

Fig. 5. Asques de *Merismatium deminutum* observées dans l'eau. a) asque avec jeunes spores (nasse apicale visible dans la chambre oculaire); b) asque avec spores mûres et trois cellules globuleuses surnuméraires; c) détail de la chambre oculaire (nasse non représentée) d'un jeune asque. M, Arnold, Eichstätt, 1861, topotype.

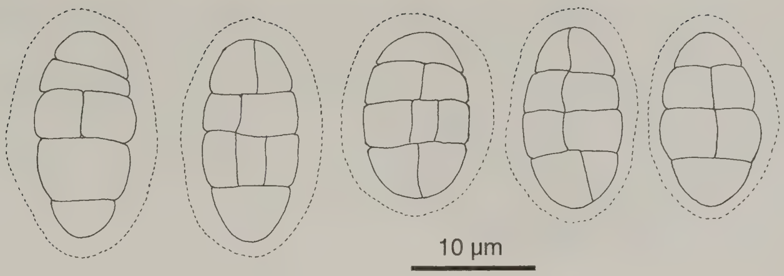

Fig. 6. Spores de *Merismatium deminutum* subsp. *deminutum* observées dans l'eau. M, Arnold, Eichstätt, 1861, topotype.

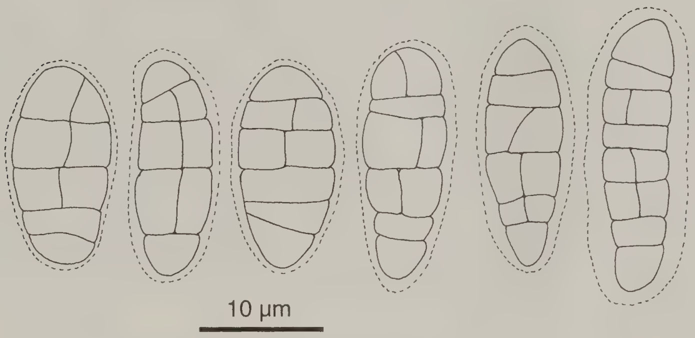

Fig. 7. Spores de *Merismatium deminutum* subsp. *longisporum* observées dans l'eau. Holotype.

Un spécimen récolté en Catalogne méridionale (province de Tarragona, BCC-lich. 13853, voir plus loin la section Spécimens examinés), à l'étage mésoméditerranéen, sur le thalle de *Staurothele orbicularis,* se distingue par des spores à halo inhabituellement mince (ca. 1 µm) et à spores légèrement plus petites [(19)19,5–*21,2*–23(25) × (8)9,5–*10,6*–11,5(12), à rapport longueur sur largeur de (1,6)1,8–2,0–2,3(2,6)]. Il sera nécessaire d'étudier d'autres spécimens des parties basses de la région méditerranéenne avant de se prononcer sur leur statut taxonomique.

Dans les Alpes de Savoie, à l'étage subalpin supérieur et à l'étage alpin, les *Merismatium deminutum* montrent des spores (fig. 7) assez différentes de celles des spécimens typiques : plus longues et plus étroites, de (18)24–*26,3*–29,5(34) × (7,5)8,5–*10,3*–12,5(12,5) µm, à rapport longueur sur largeur de 2,0–*2,6*–3,4(4), et avec davantage de cloisons transversales, (3)4–6(7), et moins de cloisons longitudinales, (0)1–4 (statistique établie d'après la mesure de 33 spores mûres). Outre l'écologie, ces spécimens différant par des caractères peu importants dans les dimensions et le cloisonnement des spores, nous proposons la description d'une nouvelle sous-espèce :

Merismatium deminutum subsp. ***longisporum*** Cl. Roux et Nav.-Ros. subsp. nov.

Differt a subspecie deminutum *sporis longioribus et angustioribus, (21)24–*26,3*–30(34) × (7,5)8,5–*10,3*–12,5(12,5) µm, cujus longitudo ad latitudinem est 2,0–*2,6*–3,4(4), cum pluribus transversis septis, (3)4–6(7), et paucioribus in longitudinem porrectis septis, (0)1–4, atque ecologia sua (in subalpino superiore alpinoque gradu).*

En espéranto : *Diferencas de la subsp.* deminutum *pro sporoj pli longaj kaj pli mallarĝaj, (21)24–*26,3*–30(34) × (7,5)8,5–*10,3*–12,5(12,5) µm, kun rilatumo longo/larĝo de 2,0–*2,6*–3,4(4), laŭlarĝe kun pli da septoj, (3)4–6(7), laŭlonge kun malpli da septoj, (0)1–4, kaj ekologio (en la supra subalpa kaj alpa etaĝoj).*

Holotype : Francio, Savojo, Nacia Naturparko de Vanoise, 500 m je ENE de la ĉaledoj de Glières, sur roksurfaco el triasa kalkopetro, N–orientiĝa, 70° dekliva, en *Lecideetum cavatulae*. 1974 07 12. Alt. 2100 m. C. Roux, MARSSJ [France, Savoie, parc national de la Vanoise, à 500 m à l'ENE du chalet des Glières, sur une surface rocheuse de calcaire triasique, orientée vers le N, à pente de 70°…].

Écologie, répartition

Merismatium deminutum est un champignon lichénicole non lichénisé qui se développe généralement sur des thalles endolithiques en mauvais état, mourants ou même morts, auxquels il ne semble pas causer de dommage. Peut-être est-il au moins en partie saprophyte comme par exemple les *Sarcopyrenia*. En raison de son état, l'hôte est souvent non déterminable, mais nous avons pu l'attribuer chez certains spécimens aux genres *Verrucaria* (notamment *V. hochstetteri* Fr.), *Thelidium* [notamment *T. decipiens* (Nyl.) Krempelh.], *Polyblastia* [notamment *P. nidulans* (Stenham.) Arnold] et *Staurothele* [notamment *S. orbicularis* (Massal.) Th. Fr.].

M. deminutum et ses hôtes s'établissent sur des roches calcaires ou calcaréo-dolomitiques peu ou pas ensoleillées, généralement sur des parois verticales ou fortement inclinées, principalement dans l'*Hymenelion caerulaea* Roux 1981 nom. mut. (= *Aspicilion caeruleae*). Il a une très vaste répartition altitudinale, puisque nous l'avons rencontré essentiellement de 500 m d'altitude (à l'étage supraméditerranéen, voir Roux, 1981 : 77) jusqu'à 2600 m (étage alpin, voir Roux, 1981 : 114), mais semble commun surtout à partir de l'étage montagnard, dans des peuplements à thalles endolithiques, surtout de Verrucariaceae, dominants. Roux (1981 : 61–68) l'a cependant signalé à seulement 200 m d'altitude, dans un *Verrucarietum cazzae* Clauzade et Roux 1975, et Navarro-Rosinés, Sérusiaux, Boqueras et Etayo l'ont récolté en Belgique entre 150 et 180 m (voir la section Spécimens examinés), mais il semble rare à de telles altitudes.

Dans les Alpes de Savoie, à partir de 2000 m, dans l'*Encephalographetum cacuminae* Roux 1981, et même dans l'*Eigleretum homalomorphae* Roux 1981 nom. mut. (= *Lecideetum cavatulae*), *Merismatium deminutum* est représenté par la subsp. *longisporum*. Par contre, dans les Pyrénées orientales, dans le val de Núria, à 2200 m d'altitude, nous n'avons observé que la sous-espèce *deminutum*.

Jusqu'ici, l'espèce est connue seulement en Europe : Allemagne (Scholz, 2000), Autriche (Hafellner et Türk, 2001), Belgique (Diederich et Sérusiaux, 2000), Espagne (Llimona et Hladun, 2001), France, îles Britanniques (Purvis *et al.*, 1992), Italie (Nimis, 1993), Pologne (Alstrup et Olech, 1988), Slovaquie (Servít, 1954), Slovénie (Suppan *et al.*, 2000), Suède (Santesson, 1993), Suisse (Zschacke, 1933–1934 ; Ruoss *et al.*, 1988). La plupart des mentions concernent les régions montagneuses et la région méditerranéenne.

Spécimens examinés

Merismatium deminutum (Arnold) Cl. Roux et Nav.-Ros.

Sauf mention contraire les spécimens se trouvent sur des thalles endolithiques indéterminables, en mauvais état, morts ou mourants.

subsp. *deminutum*

Allemagne : • [Bavière, Jura de Franconie], Dolomitfelsen des Wintershofer Bergabhangs bei Eichstätt. 1860. F. Arnold, M, holotype. • [Bavière, Jura de Franconie], Dolomitfelsen des Wintershofer Bergabhangs bei Eichstätt. 1861. F. Arnold, M, topotype. • [Bavière, Jura de Franconie], Kalkfelsen der Schlucht zwischen Schönfeld und Eßling bei Eichstätt. 1861. F. Arnold, M. • [Bavière, Jura de Franconie], Kalkfelsen oberhalb Neuessing im Altmühlthale bei Kelhaim. 1863. F. Arnold, M. • [Bavière, Jura de Franconie], an einem Kalkfelsen im Altmühlthale unterhalb Schönfeld bei Eichstätt. 1861/06. F. Arnold, Lich. Exs. n° 200,

M. • [Bavière, Alpes bavaroises, Chiemseer Berge], Kalkblöcke am Abhänge unter der Kampenwand bei Aschau. 1875/09. F. Arnold, M. [2 spécimens, l'un sur *Verrucaria hochstetteri* en très mauvais état, l'autre sur *Thelidium decipiens*]. • [Bavière, Alpes bavaroises, Chiemseer Berge], Kalkhornstein auf dem Hochgern. Alt. 5000' [1590 m]. 1869/08. F. Arnold, M. • [Bavière, Alpes bavaroises], Kalkfelsen ober[halb] St. Anton bei [Garmisch-]Partenkirchen. 1868/07. F. Arnold, M. • [Bavière, Alpes bavaroises], Kalkblöcke ober dem Taubensee bei Wessen [= Oberwössen]. 1872/09. F. Arnold, M [sur *Polyblastia nidulans*].

Autriche: [Tyrol], Kalkfelsen der Matreier Grube ober der Waldrast. Alt. 6000' [1900 m]. 1869/07. F. Arnold, M.

Belgique: Prov. Namur, Dinant, Devant-Bouvignies (Reserva Natural) 91081300, 150–180 m, calcària devoniana (limestone). 1991/08/13, leg. P. Navarro-Rosinés, E. Sérusiaux, M. Boqueras et J. Etayo, BCC-lich. 13338. Sur le thalle endolithique d'une Verrucariaceae non déterminable.

France: • Franche-Comté, Jura, réserve naturelle du Haut-Jura, commune de Crozet, le Grand Crêt. Alt. 1600 m. 2001/09/02. C. Gueidan, n° 325 (avec *Polyblastia albida* Arnold et *Thelidium* cf. *absconditum* (Hepp) Rabenh.) et n° 310 (avec *Polyblastia fuscoargillacea* Anzi). • Haute-Savoie, commune de Monnetier-Mornex, le Petit Salève, camp des Allobroges, sur calcaire compact et très cohérent. Alt. 900 m. 2001/08/22. C. Gueidan, n° 561. Avec *Toninia athallina* (Hepp) Timdal, sur le thalle endolithique d'une Verrucariaceae non déterminable. • Var, Mons, E de la bieno Bourrigaille, N flanko de Pey-Gros, sur surfaco el kompakta k tre kohera kalkopetro, NNE orientiĝa, 20° dekliva, en *Verrucarietum marmoreae* kun *Lecanora agardhiana,* registro 1975 10 23/02. Alt. 750 m. Cl. Roux, MARSSJ. • Var, Nans-les-Pins, partie supérieure du vallon de Castelette, cirque rocheux au-dessus et à l'E de la source de l'Huveaune, sur paroi rocheuse de calcaire très cohérent et compact, orientation générale N, orientation locale N, Alt. 580 m. 2000/03/03. Cl. Roux n° 22825, MARSSJ.

Espagne, Catalogne: •Prov. Girona, Ripollès, Queralbs, Fontalba, UTM 31T29, 2200 m alt., superfícies de roca calcària inclinades (60°) orientades al NNE, 1986/07/18, P. Navarro-Rosinés, BCC-lich. 4272. Sur le thalle de *Verrucaria hochstetteri* var. *obtecta* (Müll.Arg.) Clauz. et Cl. Roux. •Prov. Tarragona, Alt Camp, Aiguamúrcia, prop de l'ermita de Sta. Agnes, UTM 31TCF6981, 500–600 m alt., blocs de roca calcària, orientació NNE. 1988/02/20, P. Navarro-Rosinés, M. Giralt et A. Gómez-Bolea, BCC-lich. 13853. Sur le thalle de *Staurothele orbicularis.*

Italie: Prov. Bozen [(Südtirol), Dolomiten] Dolomit des Schlern-Abhanges oberhalb der Seisseralpe. 1867/07. F. Arnold, M.

subsp. *longisporum* Cl. Roux et Nav.-Ros.

Outre le type (voir plus haut, section Variabilité) :

- **France** : Savojo, Nacia Naturparko de Vanoise, tute apude kaj SSU de lago Assiettes, apud la rifuĝejo Felix-Faure, sur krutaĵo el kompakta kaj tre kohera kalkopetro N-orientiĝa, 70° dekliva, en *Encephalographetum cacuminum*. 1974 07 12/01. Alt. 2440 m. C. Roux, MARSSJ.

***Merismatium discrepans* (Lahm) Triebel**

Belgique : Prov. Namur, Dinant, davant Bouvignies (Reserva Natural), 91081300, 150–180 m, calcària devoniana (limestone). 1991/08/13, P. Navarro-Rosinés, E. Sérusiaux, M. Boqueras, J. Etayo, BCC-lich. 13336. Sur le thalle de *Protoblastenia rupestris* (Scop.) J. Steiner.

Espagne, Catalogne : Prov. Girona, Ripollès, Queralbs, Fontalba, UTM 31T29, 2200 m alt., superfícies de roca calcària inclinades (60°) orientades al NNE, 18/07/1986; P. Navarro-Rosinés (BCC-lich. 4379 et 4380). Sur le thalle de *Protoblastenia rupestris*.

Suisse : Valezo, Trient, 15 km NE de Chamonix (Francio, Savojo), 0,8 km de la landlimo, supro Croix-de-Fer, tuj sub la supro, sur krutaĵo el kalkopetro tre kohera, ĝen. orient. NU, loka orient. NU. Alt. 2340 m. Cl. Roux n° 20326, MARSSJ [Sur *Hymenelia epulotica* (Ach.) Lutzoni, phycotype à algue protococcoïde].

***Merismatium scammoecum* Lettau**

Allemagne : [Bavière, Alpes bavaroises], Kalkfelsen ober[halb] St. Anton bei [Garmisch-]Partenkirschen in Südbayern. 1868/07. F. Arnold, M (sub *Polyblastia deminuta*).

Espagne, Catalogne : Prov. de Lleida, Alt Urgell, Figols i Alinyà, entre el Pedró dels Quatre Batlles i el Prat Llarg, UTM 31TCG7671–7771, 2200–2382 m alt., pedres i lloses calcàries dels prats alpins. 2001/06/30, P. Navarro-Rosinés, E. Gaya, A. Gómez-Bolea, BCC-lich. 13854. Sur le thalle en mauvais état d'une Verrucariaceae endolithique.

Clé de détermination des espèces de *Merismatium* et de *Pleosphaeria lichenothricis*

Cette clé tient compte des données de Clauzade *et al.* (1989), Triebel (1989) et bien sûr du présent travail.

11 Spores au moins au début halonées.— Sur lichens crustacés saxicoles calcicoles généralement en mauvais état — Fig. 6–10 —

22 Spores en totalité ou pour la plupart ≥ 20 µm de long, à (5)6–9(10) cellules. Paroi ascomale brun sombre ou brun noirâtre au sommet. — Europe. Sur lichens à thalle endolithique (Verrucariaceae spp. et thalles non déterminés). — Syn. *Polyblastia deminuta* Arnold —
1. ***M. deminutum*** (Arnold) Cl. Roux et Nav.-Ros.

αα Spores de (19,5)20–28(29,5) × (10)11–15(17) µm, à rapport L/l de 1,5–2,0(2,3), à 3–4(5) cloisons transversales et (1)3–4(6) cloisons longitudinales. — De l'étage supraméditerranéen à l'étage montagnard, plus rarement à l'étage subalpin —
subsp. ***deminutum***

α Spores de (21)24–30(34) × (7,5)8,5–12,5(12,5) µm, à rapport L/l de 2,0–3,4(4), à (3)4–6(7) cloisons transversales et (0)1–4 cloisons longitudinales. Alpes de Savoie, étage subalpin supérieur et étage alpin — subsp. ***longisporum*** Cl. Roux et Nav.-Ros.

2 Spores pour la plupart ≤ 20 µm. Paroi ascomale vert noirâtre au sommet.

33 Spores (13)15–20(22) × (8)10–13(15) µm, à (1)4–6(8) cellules. — Autriche, Allemagne, Belgique, Espagne (Catalogne), Suisse. Sur *Protoblastenia, Verrucaria dufourii* et *Thelidum* —
2. ***M. scammoecum*** Lett.

3 Spores 11–15(18) × 7–10(12) µm, à (1)4(6) cellules. — Europe et Afrique du Nord. Sur *Protoblastenia, Hymenelia, Verrucaria dufourii, Aspicilia contorta.*— Syn. *Polyblastia discrepans* Lahm — **3.** ***M. discrepans*** (Lahm) Triebel

1 Spores non halonées. Ascomes à paroi brun noir au sommet. — Sur des lichens terricoles, muscicoles, corticoles, rarement saxicoles. — *Merismatium* s.s. —

22 Spores pour la plupart de 15–25 × 8–12 µm, murales au moins à la fin. Ascomes de 0,1–0,3 mm.

33 Spores murales dès le début, noirâtres à la fin, de 17–24 × 6–13 µm. Ascomes ovoïdes ou fusiformes. — Floride. Parasymbiote de *Lichenothrix riddlei* Hensen, l'ensemble constitué par le parasymbiote et le *Lichenothrix* (toujours stérile), autrefois considéré par Riddle comme un lichen fertile : *Pyrenothrix nigra* Riddle —
4. ***Pleosphaeria lichenothricis*** Henssen

3 Spores d'abord submurales, puis murales, brunes (jamais très sombres), de (14)15–25(32) × (6)8–12(15) µm. Ascomes globuleux ou piriformes, dispersés ou groupés. — Europe. Sur de nombreux lichens crustacés ou squamuleux, notamment *Lopadium pezizoideum, Catapyrenium* spp., *Protoblastenia* spp. — Syn. *M. lopadii* (Anzi) Zopf, *Polyblastia nigritella* (Nyl.) Arnold. — Incl. *M. lecanorae* (Oliv.) Vouaux à spores de 25–40 × 10–16 µm, d'un beau brun jaune, sur le thalle ou les apothécies de *Ochrolechia parella* — **5. *M. nigritellum*** (Nyl.) Vouaux

2 Spores ≤ 19 × 8 µm, submurales ou à 3 cloisons plus ou moins obliques.

33 Ascomes de 0,05–0,1 mm, globuleux. Spores de 8–16 × 4–8 µm, à 4–8 cellules. — Europe. Sur des lichens corticoles, lignicoles ou muscicoles *(Biatora vernalis, Lopadium disciforme, Myxobilimbia sabuletorum).*— Syn. *Phaeospora consocians* (Nyl.) Vouaux — **6. *M. heterophractum*** (Nyl.) Vouaux

3 Ascomes de 0,1–0,3 mm, globuleux.

444 Spores de 12–17 × 4–7 µm, à (2)4 cellules, cloisonnées seulement transversalement, brun moyen ou brun sombre.— ex U.R.S.S., Autriche, Allemagne, Italie. Sur *Rimularia gibbosa* et *R. badioatra* (saxicoles-calcifuges)— **7. *M. peregrinum*** (Flot.) Triebel

44 Spores de 10–18 × 3–6 µm, à 4(5)cellules. — Europe et Amérique du Nord. Sur lichens muscicoles et terricoles *(Lopadium, Mycobilimbia, Saccomorpha, Trapeliopsis)* — **8. *M. decolorans*** (Rehm ex Arnold) Triebel

4 Spores de 8–19 × 5–8 µm, à 4–6(8) cellules. — Europe du Nord, ex U.R.S.S. et Amérique du Nord. Sur lichens saxicoles-calcifuges *(Amygdalaria, Euopsis)* — **9. *M. coccisporum*** (Norm.) Vouaux

Discussion

Le genre *Polyblastia* A. Massal. est aujourd'hui encore bien mal connu et peut-être hétérogène, même si l'on en exclut les espèces, non saxicoles, qui relèvent du genre *Agonimia* Zahlbr. (Sérusiaux *et al.*, 1999). Si on se limite aux espèces saxicoles-calcicoles à thalle endolithique, les seules directement concernées par la discussion, on peut y distinguer deux groupes, l'un caractérisé par des ascomes plus ou moins entièrement enfoncés dans la roche et dépourvus d'involucrellum, l'autre par des ascomes plus ou moins saillants et munis d'un involucrellum, groupe auquel appartient le type du genre, *P. cupularis* Massal.

Polyblastia deminuta Arnold, dépourvu d'involucrellum du fait de son caractère non lichénisé, diffère des *Polyblastia* sans involucrellum par des spores distinctement halonées, une paroi ascomale à structure en partie du type *textura angularis* et par son caractère lichénicole non lichénisé. Ces caractères sont d'une importance toute relative, et il serait possible de laisser provisoirement *Polyblastia deminuta* dans les *Polyblastia,* dans l'attente de leur révision, s'il n'existait un genre de champignons lichénicoles déjà décrit, révisé par TRIEBEL (1989), où *Polyblastia deminuta* prend beaucoup plus naturellement place, le genre *Merismatium* Zopf.

Polyblastia deminuta se rapproche en effet beaucoup du groupe de *Merismatium discrepans* et de *M. scammoecum* (TRIEBEL, 1989 : 178) par tous ses caractères essentiels, en particulier par la structure de ses ascomes, son hamathécium, ses asques et ses spores distinctement halonées. Il n'en diffère que par le sommet de ses ascomes dépourvu de pigment vert sombre et par ses spores plus grandes (voir fig. 8–10 et, plus haut, la clé de détermination). *M. scammoecum,* qui s'établit principalement sur des Verrucariaceae à thalle endolithique en mauvais

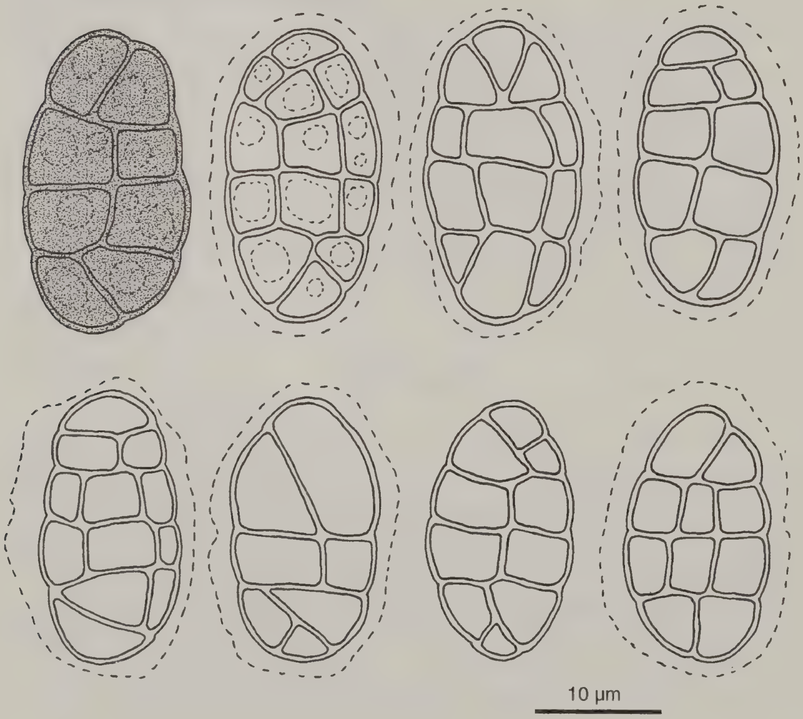

Fig. 8. Spores de *Merismatium deminutum* subsp. *deminutum* (BBC-lich n° 13338) observées dans l'eau. Pigment figuré seulement sur la première spore en haut et à gauche ; guttules seulement sur les deux premières.

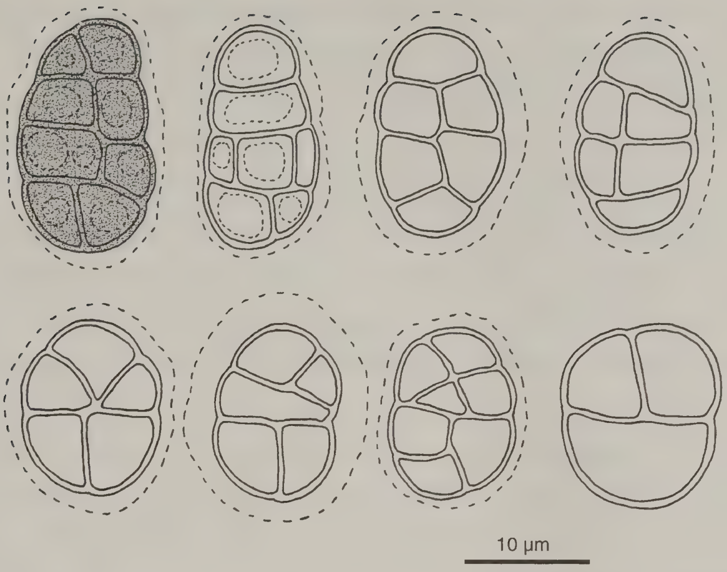

Fig. 9. Spores de *Merismatium scammoecum* (BBC-lich n° 13854) observées dans l'eau. Pigment figuré seulement sur la première spore en haut et à gauche ; guttules seulement sur sur les deux premières.

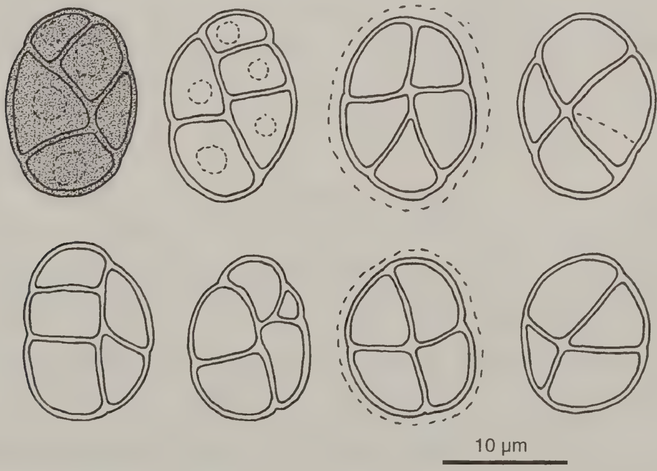

Fig. 10. Spores de *Merismatium discrepans* (BBC-lich n° 4379) observées dans l'eau. Pigment figuré seulement sur la première spore en haut et à gauche ; guttules seulement sur sur les deux premières.

état, a d'ailleurs été confondu avec *Polyblastia deminuta* par ARNOLD lui-même (voir la section Spécimens examinés).

Le groupe de *Merismatium nigritellum* (espèce type du genre *Merismatium*) étant caractérisé (TRIEBEL, loc. cit.) par des spores non halonées et un sommet ascomal dépourvu de pigment vert, on voit que *P. deminuta* est intermédiaire entre ces deux groupes qui ne diffèrent en réalité que leur périspore formant ou non un halo distinct.

TRIEBEL (1993) place le genre *Merismatium* dans l'ordre des Verrucariales et la famille des Verrucariaceae en même temps que cinq autres genres de champignons lichénicoles. Effectivement, par son hamathécium (périphyses et pseudoparaphyses de type b), la structure et la déhiscence de ses asques, et sa gelée hyméniale hémiamyloïde, caractères que présentent tous les genres de Verrucariaceae lichénisés (par exemple *Verrucaria* Schrader, *Thelidium* A. Massal., *Polyblastia* A. Massal., *Staurothele* Norman) ou non (par exemple *Endococcus* Nyl., *Muellerella* Hepp ex Müll. Arg., *Phaeospora* Hepp), il nous semble clair que *Merismatium* prend naturellement place dans la famille des Verrucariaceae, au voisinage des *Polyblastia,* et dérive peut-être de ce genre par perte de la lichénisation.

Remerciement

Nous remercions très vivement H. HERTEL et D. TRIEBEL (München) pour le prêt des spécimens de *Polyblastia deminuta* de l'herbier de F. ARNOLD. Le travail de recherche du troisième auteur (P. N.-R.) s'inscrit dans le cadre du projet PR 96–1115. C04. 02 subventionné par la DGESIC (Espagne).

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PECCANIA SALEVENSIS AND SYNALISSA NITIDULA BELONG TO THE GENUS PAULIA (LICHINACEAE)

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Abstract: The generic placement of the cyanobacterial lichens *Peccania salevensis* and *Synalissa nitidula* is clarified based on type material studies. Both species are shown to be members of the genus *Paulia* in the Lichinaceae. Therefore, the new combinations *Paulia salevensis* and *Paulia nitidula* are made. The position of the species within *Paulia* is briefly discussed.

Key words: Lichinales, lichenized ascomycetes, Socotra, Mnt. Salève

Introduction

The genus *Paulia* in the cyanobacterial lichen family Lichinaceae currently contains 12 species. The homoiomerous thallus anatomy with large, coccoid photobiont cells surrounded by a loose network of thin, elongated mycobiont cells, the presence of eight, thick-walled ascospores, the lack of a proper exciple and a preference for dry coastal or island habitats mainly in tropical and subtropical regions are characteristic (Henssen 1986). Whereas all these features seem to be constant in the genus, the thallus growth form varies considerably among the species, e.g. squamulose-tessellate, rosette-shaped, irregularly subfruticose, caespitose, dichotomously-fruticose (Henssen 1979, Henssen 1986, Henssen & Tretiach 1995, Tretiach & Henssen 1996).

When studying the generic relationships in the family Lichinaceae as well as the distribution of members of the Lichinaceae in the southern Arabian region the type material of *Peccania salevensis* (Müll.Arg.) Forssell and *Synalissa nitidula* Müll.Arg. was examined focussing on the generic position of these extremely rare and poorly understood lichens.

Material and Methods

Cryotome sections (16-20 µm thick) were stained with lactophenol cotton blue. Anatomical measurements were made using semi-permanent mounts. The iodine reaction was tested after pretreatment with KOH. Micrographs were taken using a Zeiss (Jena) Axioskop. Macrographs were taken with a Nikon F3 camera using a Zeiss Luminar 40 mm lens mounted on bellows. Unless otherwise indicated the specimens are kept in the collectors' private herbaria: M. Schultz (Hamburg), B. Büdel (Kaiserslautern) and B. Mies (Duisburg).

The following selected material was used for comparative studies: ***Paulia aldabrensis*** Henssen: YEMEN: Socotra, c. 20 km SE of Hadibu, trail to Nogeed, valley slope with limestone boulders, c. 200 m, 12°31. 7'N, 54°10. 6'E, 16.03.1997, *M. Schultz* 14029a. Ant Kashara, Mumi plateau, limestone boulders, 560 m, 13.01.1994, *B. Mies* [12886] *& C. Printzen*. – AUSTRALIA: Queensland, Trinity Bay, coastal road, 17.08.1987, *B. Büdel* [18047b] *& H.T. Lumbsch*. ***Paulia caespitosa*** Tretiach & Henssen: AUSTRALIA: NE New South Wales, Lord Howe Isl., Boat Harbour, on basalt rocks along the foreshore in disturbed lowland vegetation with palms, 3 m, 31°33'40''S, 159°05'50''E, 10.02.1995, *J.A. Elix* 42467 (as *Lichina*) (CBG). – MEXICO: SW Chihuahua, Mpio Bocoyna, valley of Basiguare, 21 km S of Cusarare, on vertical rock, 01.88.1977, *W.A. Weber & R. Bye* [Weber, *Lich. exs. Colo.* no. 576] (as *Peccania* spec. indet.) (B 186; BM). Baja California, 5 km N of San Juanico along an old coral reef, Magdalena Region of the Sonoran Desert, 50 m, 26°18'25''N, 112°29'25''W, 04.01.1998, *T.H. Nash III* 39800 (ASU). – YEMEN: W of Hawf, rocky slope facing the coast, on limestone, c. 25 m, 16°37.2'N, 52°58.3'E, 13.10.2001, *M. Schultz* 14121a. ***Paulia gibbosa*** Henssen: VENEZUELA: Edo. Amazonas, Pto. Ayacucho, Est. Experim. Amazonas, fon-IAP, granite inselberg near the air port, c. 05°40'N, 67°40'W, May 1996, *B. Büdel* [24046b, 24057b, 24110a] *& M. Schultz*. ***Paulia myriocarpa*** (Zahlbr.) Henssen: YEMEN: Socotra, Mumi plateau, near Shilhin, c. 35 km SE of Hadibu, steep limestone faces, c. 450 m, 12°31.3'N, 54°19.0'E, 22.03.1997, *M. Schultz* 14060e. – VENEZUELA: Edo. Bolívar, Guaniamo, c. 120 km S of Caicara del Orinoco, *U. Lüttge* 4a. Edo. Amazonas, Pto. Ayacucho, Est. Experim. Amazonas, fon-IAP, granite inselberg near the air port, c. 05°40'N, 67°40'W, May 1996, *B. Büdel* [24046a, 24057a, 24110b] *& M. Schultz*. – MEXICO: Baja California, Sierra de la Laguna, camp close to Todos Santos, rocky slope, on granite rock faces, 600-700 m, 23°30'N, 110°00'W, 15.02.1993, *B. Büdel* 20155, 20162. ***Paulia perforata*** (Pers.) Asah.: YEMEN: Socotra, c. 4.5 km S of Hadibu, ascent to Muqadrihon pass, on limestone boulder, c. 250 m, 12°36.8'N, 54°0.75'E, 19.03.1997, *M. Schultz* 14045e and roughly the same area, 12°36.5'N, 54°0.3'E, 08.04.1993, *B. Mies* 12596. Top of Dixam plateau at the lake, dolomitic limestone, 940 m, 12°31'N, 53°57'E, 27.01.1998, *B. Mies* 14589; Wadi Ayeb, valley 5 km SW of Hadibu, in limestone clefts, 300 m, 19.01.1994, *B. Mies* [12989] *& C. Printzen*. ***Paulia schroederi*** (Zahlbr.) Henssen: KENYA: Mombassa, on coastal limestone, *Schröder* (WU - holotype).

Results and Discussion

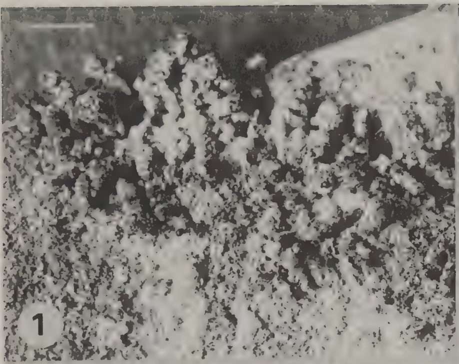
Paulia salevensis (Müll.Arg.) M.Schultz comb. nov.

Basionym: *Synalissa salevensis* Müll.Arg., Flora 45: 81 (1862).

Synonym: *Peccania salevensis* (Müll.Arg.) Forssell, Nova Acta Reg. Soc. Scient. Upsal. 13: 90 (1885).

Type: France, sur des parois de rochers du Salève au-dessus de Veyrier, sur lesquelles coule presque costamment un peu d'eau (Pas de l'Echelle?), J. Müller Argov., 21.10.1860 (G - lectotype, selected here; G, B 35939, BM - isolectotypes).

Fig. 1-3) *Paulia salevensis.* **1)** thallus irregularly fruticose, lobes cylindrical to club-shaped, pruinose; isolectotype (G). **2)** Terminal apothecia; isolectotype (B 35939). **3)** Thallus section with large photobiont cells and thin, elongated hyphae; lectotype (G). **4 & 5)** *Paulia nitidula.* squamulose-tessellate thalli; Schultz 14060f, Schultz 14105a. **6)** *Paulia schroederi*; fertile, bulging, squamulose-tessellate thalli; holotype (WU 3733). **7 & 8)** *Paulia nitidula.* **7)** small, sterile, squamulose-tessellate thallus; holotype (G). **8)** Thallus section showing growth form and anatomy; Schultz 14105a. Scale bar: figs. **1, 2, 4-7** = 2 mm; figs. **3** = 25 µm; fig. **8** = 50 µm.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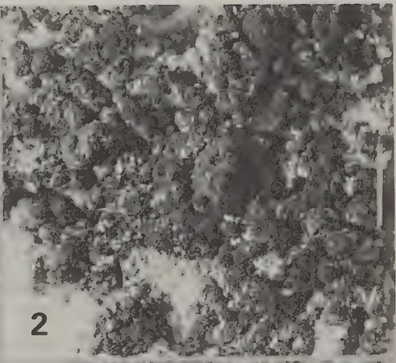
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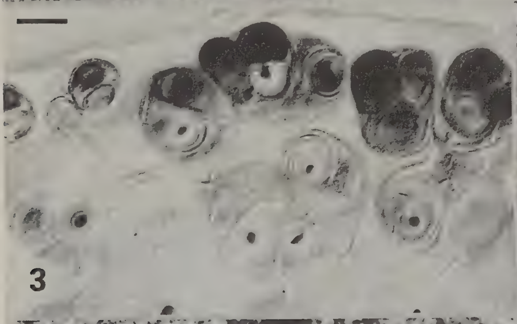
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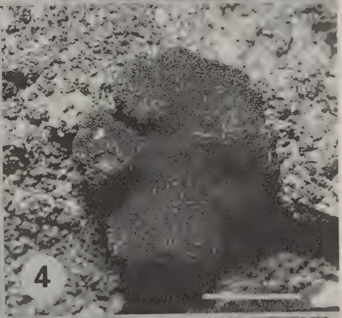
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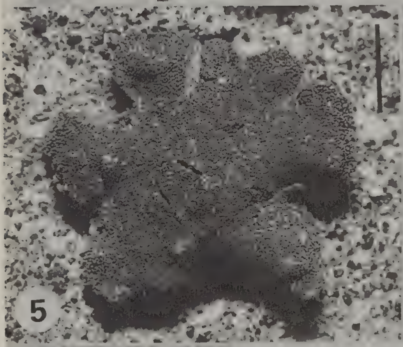
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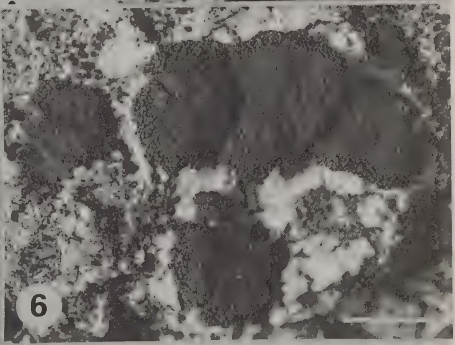
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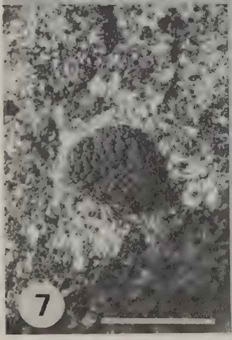
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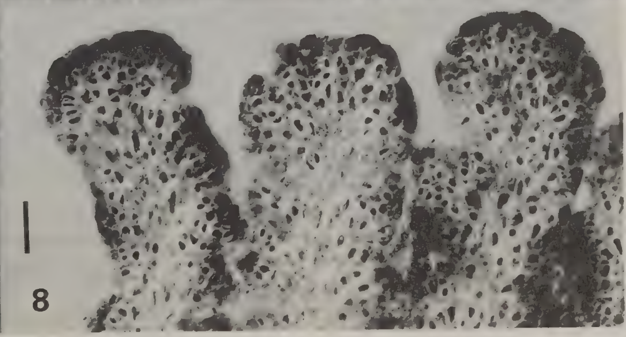
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The species is only known from the type locality at Mnt. Salève, France close to the Swiss boarder near Geneva. The collection in the herbarium of Müller Argoviensis in G consists of three packets all labelled by the hand of the describing author and all containing the same species. One packet contains brilliant drawings of anatomical details marked "Fig. 17" but lacks indications of the type locality (fig. 9). These drawings were reproduced in the species description by Müller Argoviensis (1862) in "pl. 2, fig. 17". Apparently, Müller Argoviensis referred the species description to the specimen in the packet containing his drawing "Fig. 17". The second packet contains two rough ink drawings of ascus and ascospores, a short description, a date ("21.10.1860") and the type locality ("an ... Felsblöcken des Salève ... Pas de l'Echelle ..."). The third packet contains notes of the describing author on gonidial structures but lacks any references to the type locality. Nevertheless, we consider all three samples as syntypes and select the sample which is accompanied by the excellent anatomical drawings as lectotype. In doing so, the other two samples become automatically isolectotypes. Further material was seen in B and BM. It agrees with the material in G and with the original diagnosis. Therefore, we consider these samples as syntypes of the original collection which become further isolectotypes. Later, *Synalissa salevensis* seemed to be recorded only once. It was recollected at the type locality by Jacques Rome in 1881 (pers comm. by Philippe Clerc, G). Hence, this material would be a topotype.

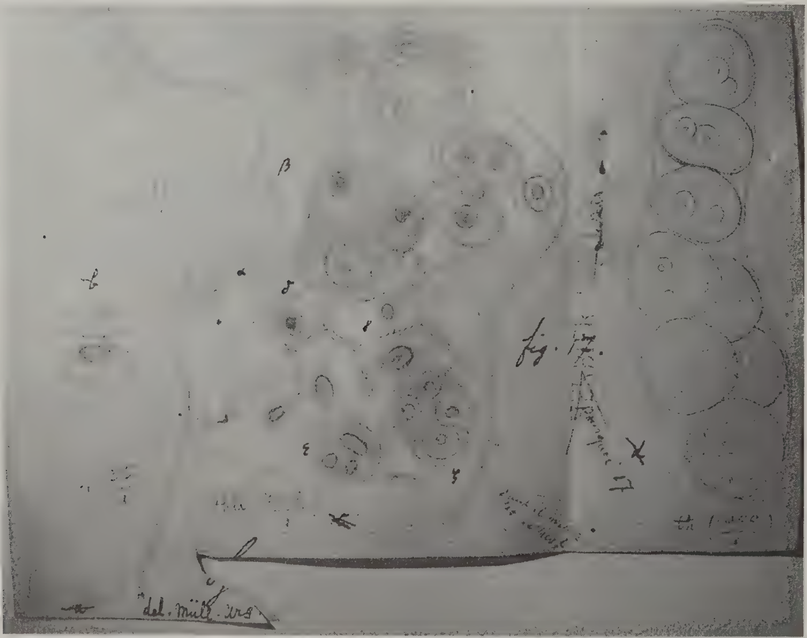

Fig. 9: Drawings of *Synalissa salevensis* by J. Müller Argov. accompanied by one of the syntypes kept in G; marked "Fig. 17" and reproduced in the protologue (Müller Argov. 1862, pl. 2, fig. 17).

The species is fruticose with at least in part greyish pruinose (fig. 1), ± cylindrical lobes that become club shaped especially when carrying apothecia (fig. 2). It was transferred to *Peccania* by Forssell (1885) on account of the yellowish colour of the gelatinous sheath of the photobiont cells. Species of *Synalissa* are fruticose and the gelatinous sheath is reddish or purplish whereas it is yellowish to brownish in *Peccania*. However, Forssell (1885) already mentioned that the conidia are small and ellipsoid and do not agree with the large falcate to sigmoid conidia of other *Peccania* species including the type species (see fig. 8E, p. 55; Schultz & Büdel 2002). Furthermore, *Synalissa salevensis* lacks the conspicuous reddish or brownish colouration of the hymenium and has no central hyphal strand (both features typically found in *Peccania*) and lacks a thin proper exciple (usually present in *Synalissa*). In our opinion *Synalissa salevensis* can neither be placed in *Peccania* nor in *Synalissa* as currently circumscribed. The thick-walled ascospores, the loose, reticulate anatomy with large photobiont cells (fig. 3) and the lack of a proper exciple are characteristic features in the genus *Paulia* (Henssen 1986). Therefore, we suggest to transfer *Synalissa salevensis* to *Paulia*. It is the third species of the genus having a distinctly fruticose growth form (descriptions of *Paulia caespitosa* and *P. wrightii* in Tretiach & Henssen 1996) and it is the second species from Europe beside *P. glomerata* Henssen & Tretiach (see Henssen & Tretiach 1995).

***Paulia nitidula* (Müll.Arg.) M.Schultz comb. nov.**
Basionym: *Synalissa nitidula* Müll.Arg., Proc. Royal. Soc. Edinburgh 11: 457 (1882).
Type: Yemen, Socotra, on limestone, Balfour no. 1467 (G - holotype, seen).

The holotype of *Synalissa nitidula* in G consists of two tiny, flat, roundish squamules one of which having a distinctly tessellate surface (fig. 7). The thallus anatomy is loosely reticulate with large, coccoid photobiont cells surrounded by thin, elongated fungal cells. *Synalissa nitidula* resembles *Paulia* species, especially *P. gibbosa* Henssen and *P. schroederi* (Zahlbr.) Henssen (fig. 6). Both lichens have similar squamulose, umbilicate thalli with a finely tessellate surface. They differ from each other in the colouration of the apothecial discs and the distribution patterns (Henssen 1986, Henssen & Jørgensen 1990). *Paulia gibbosa* is known from the Bermudas and Venezuela, *P. schroederi* is so far only known from coastal limestone near Mombassa, Kenya. *Paulia myriocarpa* (Zahlbr.) Henssen is the third squamulose-tessellate species in the genus, but has larger surface areoles, a distinctly effigurate margin and a distribution area ranging from Socotra to Brazil, Venezuela and western coastal Mexico (Henssen 1986, Schultz et al. 1999).

Unfortunately, the holotype of *Synalissa nitidula* is sterile as are those specimens collected by the first author and Dr. Bruno Mies on Socotra in 1997 and in SE Yemen in 2001 (figs. 4 & 5). Since the holotype and the new collections perfectly agree in thallus growth form and thallus anatomy with *Paulia schroederi* and *P. gibbosa*, it seems to be likely but impossible to decide whether *Synalissa nitidula* is conspecific with either *Paulia schroederi* or *P. gibbosa*. Nevertheless, the striking similarities in thallus anatomy and the tessellate thallus surface (figs. 4, 5, 7 & 8) justify the placement of the species in *Paulia* instead of *Synalissa*, a genus containing strictly fruticose species. Therefore, *Synalissa nitidula* is transferred to *Paulia*, but will be retained as a separate species at least for the moment.

Additional specimen examined: YEMEN: Socotra, Wadi Ayhaft, S of Djebel Rughid, 230 m, 12°36'N, 53°59'E, 1998, *B. Mies* 14460; Djebel Hawari E of Suk, E of Hadibu, 50 m, on limestone, 12°40'N, 54°03'E, 1997, *B. Mies* 14049; Mumi plateau, near Shilhiń, c. 35 km SE of Hadibu, steep limestone faces, c. 450 m, 12°31.3'N, 54°19.0'E, 22.03.1997, *M. Schultz* 14060f (specimen cited as *Paulia schroederi* in Schultz et al. 1999). SE peninsula Yemen, Ras Fartak, plateau S of Djebel Hadaba, inclined limestone boulders, c. 600 m, 15°49.4'N, 51°58'E, 09.10.2001, *M. Schultz* 14105a.

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THE LICHEN FLORA OF TWO SITES IN THE MOJAVE DESERT, CALIFORNIA, USA

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ABSTRACT

Forty lichen species in 24 genera were identified from selected sites in the Mojave National Preserve, California. Collections were made from north-facing basalt flows, on rock, soil, and dead wood. Environmental conditions in the Mojave Desert (extreme heat and drought) generally restrict development of lichen communities except in protected locations. Saxicolous lichen communities were best developed along north-facing aspects of extensive basalt flows. South-facing exposures were completely devoid of lichens. Common saxicolous lichens, included *Dermatocarpon miniatum, Lecanora garovaglii, Lobothallia praeradiosa, Pleopsidium flavum, Rhizoplaca melanophthalma,* and *Thyrea confusa.* Terricolous lichen communities were generally patchy and poorly developed but showed best development along the edges of ephemeral watercourses. Terricolous lichens included *Collema tenax, Peltula obscurans* var. *hassei,* and *Placidium squamulosum. Xanthoria fallax* was locally common on decorticated branches of Blackbrush (*Coleogyne ramosissima)* and occasionally on Creosote bush (*Larrea tridentata).*

Key words: basalt flows, aspect

INTRODUCTION

Previous work- In Hasse's 1913 treatment of the lichens of southern California he described the lichen floras of three topographical regions (coastal, mountain, and desert) in the region. In that publication he listed a limited number of lichens for the Mojave Desert. Doell (1999) and members of the California Lichen Society published a checklist of lichen species for the Sweeney Granite Mountains Desert Research Center, where he reported a total of 63 species in 35 genera. Microbiotic soil crusts in the Mojave Desert are not as well developed, in terms of species diversity and biomass, as in the Great Basin and the Colorado Plateau (Johansen et al. 2001). Corticolous and lignicolous lichens are rare but a few species have been reported on dead branches of desert shrubs including Blackbrush (*Coleogyne ramosissima)* and Creosote bush (*Larrea tridentata;* Hasse 1913).

Study area- Lichens were collected from two sites in the Mojave National Preserve (San Bernardino County, California). The first site was located along Kelbaker Road, 20 km southeast of Baker and 1 km east of Oro Fino Mine, along a north-facing lava flow (35° 12.315′ north latitude; 115° 52.259′ west longitude; 610 m elevation). The second site was located at the east-end of Black Tank Wash, 3 km N-NW of a cinder pit mine, along a north-facing lava flow (35° 14.424′ north latitude; 115° 44.355′ west longitude; 1160 m elevation).

MATERIALS AND METHODS

Collection, identification and deposition of specimens – Lichen specimens were collected from basalt and soil substrates at both sites. In addition, lignicolous lichens were also collected from Blackbrush (*Coleogyne ramosissima)* at the Black Tank Wash site.

Specimens were identified using standard lichen keys, taxonomic treatises and by making comparisons with herbarium material. Standard chemical spot tests were used to finalize species identifications. All specimens are deposited in the Herbarium of Nonvascular Cryptogams at Brigham Young University (BRY) in Provo, Utah, USA.

Organization of species list – Relative abundance, substrates, collection sites, and herbarium and collection numbers are listed after each species. Our scale of relative abundance is rare<common<abundant. Assignment of relative abundance categories is based on the following criteria: rare = 1-2 encounters, common = 3-9 encounters, and abundant≥10 encounters.

RESULTS

Following is an alphabetical listing of the lichen species identified from two sites in the Mojave National Preserve, California. Nomenclature follows Esslinger & Egan (1995) or subsequent on-line revisions (Esslinger 1997).

ACAROSPORA FUSCATA. Locally common on basalt at Black Tank Wash site. BRY C-38565 (St. Clair 12199).

ACAROSPORA PELTASTICA. Rare on basalt at Kelbaker Road site. BRY C-38017 (St. Clair 11255).

ACAROSPORA SMARAGDULA. Locally common on basalt at Black Tank Wash site. BRY C-38561, 38577, 38585 (St. Clair 12195, 12211, 12219).

ACAROSPORA STRIGATA. Rare-locally common on basalt at both sites. BRY C-38016, 38588 (St. Clair 11254, 12222).

ASPICILIA DESERTORUM. Rare on basalt at Black Tank Wash site. BRY C-38590 (St. Clair 12224).

CALOPLACA DECIPIENS. Rare on basalt at Kelbaker Road site. BRY C-38009 (St. Clair 11247).

CALOPLACA SAXICOLA. Common on basalt at both sites. BRY C-38014, 38556, 38576 (St. Clair 11252, 12257, 12210).

CANDELARIELLA ROSULANS. Common on basalt and soil over rock at both sites. BRY C-38544, 38569 (St.Clair 12245, 12203).

COLLEMA COCCOPHORUM. Rare on soil over rock at both sites. BRY C-38551, 38557 (St. Clair 12252, 12191).

COLLEMA CRISPUM. Rare on soil over rock at Black Tank Wash site. BRY C-38575 (St.Clair 12209).

COLLEMA TENAX. Rare-locally common on soil at Black Tank Wash site. BRY C-38579, 38582 (St. Clair 12213, 12216).

DERMATOCARPON MINIATUM. Locally common on basalt at both sites; particularly on protected vertical rock surfaces beneath overhanging horizontal ledges. BRY C-38010, 38548, 38558 (St. Clair 11248, 12249, 12192).

DERMATOCARPON VELLEREUM. Rare on basalt at Black Tank Wash site. BRY C-38570 (St. Clair 12204).

ENDOCARPON PUSILLUM. Rare on soil over rock at Kelbaker Road site. BRY C-38012b (St. Clair 11250b).

FULGENSIA DESERTORUM. Rare on soil over rock at Kelbaker Road site. BRY C-38012a (St. Clair 11250a).

HEPPIA LUTOSA. Rare-locally common on soil over rock at Kelbaker Road site. BRY C-38549 (St. Clair 12250).

LECANORA GAROVAGLII. Rare-locally common on basalt at Black Tank Wash site. BRY C- 38568 (St. Clair 12202).

LECANORA MURALIS. Rare-locally common on soil over rock at Kelbaker Road site. BRY C-38012c (St.Clair 11250c).

LECANORA PHAEDROPHTHALMA. Rare-locally common on basalt at Kelbaker Road site. BRY C-38011 (St. Clair 11249).

LECIDEA TESSELLATA. Rare-locally common on basalt at Black Tank Wash site. BRY C-38578 (St. Clair 12212).

LECIDELLA STIGMATEA. Rare-locally common on basalt at both sites. BRY C-38545, 38567 (St. Clair 12246, 12201).

LOBOTHALLIA PRAERADIOSA. Locally common on basalt at both sites. BRY C-38013, 38019, 38546, 38560, 38571, 38572 (St. Clair 11251, 11257, 12247, 12194, 12205, 12206).

PELTULA EUPLOCA. Rare on basalt at Kelbaker Road site. BRY C-38015, 38552 (St. Clair 11253, 12253).

PELTULA OBSCURANS VAR. HASSEI. Locally common on soil above basalt flow at Black Tank Wash site. BRY C-38594 (St. Clair 12228).

PHYSCIELLA CHLOANTHA. Rare-locally common on Blackbrush (*Coleogyne ramosissima)* lignum at Black Tank Wash site. BRY C-38563a (St. Clair 12197a).

PLACIDIUM ACAROSPOROIDES. Rare on basalt at Black Tank Wash site. BRY C-38583 (St.Clair 12217).

PLACIDIUM SQUAMULOSUM. Locally common on soil over rock at both sites. BRY C-38547, 38559 (St. Clair 12248, 12193).

PLEOPSIDIUM FLAVUM. Common-abundant on vertical basalt surfaces at both sites. BRY C-38007a, 38007b, 38543, 38566, 38591(St. Clair 11245a, 11245b, 12244, 12200, 12225). More exposed individuals of this species were densely pruinose.

PSORA GLOBIFERA. Rare on soil/moss over basalt at Black Tank Wash site. BRY C-38589 (St.Clair 12223).

PSORA TUCKERMANII. Rare-locally common on soil over rock at Kelbaker Road site. BRY C-38006, 38555 (St. Clair 11244, 12256).

RHIZOCARPON DISPORUM. Rare-locally common on basalt at Black Tank Wash site. BRY C-38581 (St. Clair 12215).

RHIZOPLACA MELANOPHTHALMA. Locally common on basalt at Black Tank Wash site. BRY C-38593 (St. Clair 12227).

RHIZOPLACA PELTATA. Rare-locally common on basalt at both sites. BRY C-38008, 38592 (St. Clair 11246, 12226).

THYREA CONFUSA. Common-locally abundant on basalt at both sites. BRY C-38005, 38554, 38573, 38574 (St. Clair 11243, 12255, 12207, 12208).

TONINIA SEDIFOLIA. Rare on soil over rock at both sites. BRY C-38550, 38562 (St. Clair 12251, 12196).

XANTHOPARMELIA COLORADOENSIS. Rare-locally common on basalt at Black Tank Wash site. BRY C-38564, 38586 (St. Clair 12198, 12220).

XANTHOPARMELIA MEXICANA. Locally common on basalt at Kelbaker Road site. BRY C-38018a (St. Clair 11256a).

XANTHOPARMELIA PLITTII. Common on basalt at Kelbaker Road site. BRY C-38018b, 38553 (St. Clair 11256b, 12254).

XANTHORIA FALLAX. Rare-locally common on Blackbrush (*Coleogyne ramosissima)* lignum at Black Tank Wash site. BRY C-38563b, 38580, 38584 (St. Clair 12197b, 12214, 12218).

DISCUSSION AND CONCLUSIONS

Hasse (1913) observed the variable effects of aspect, wind, and aridity on the development of lichen communities in the Mojave Desert. He also pointed out that lichen development on corticolous substrates was minimal. In our study we document Hasse's observation by showing that development of saxicolous lichen communities is limited to the north-facing aspect of basalt flows. Aspect-related shading reduced overall substrate temperature, while providing more consistent moisture, and better protection from wind damage. The two sites in our study had 11 species in common with 22 species at the Kelbaker Road site and 26 species at the Black Tank Wash site. Differences in species diversity and community development between the two areas, is at least somewhat related to the size (height and length) of the north-facing slopes. The basalt flow at the Black Tank Wash site was longer, taller, and generally more structurally complex yielding more diverse and extensive microhabitat. Soils at both sites were thin, coarse, and poorly differentiated. The lack of soil structure along with high surface temperatures and low precipitation resulted in poorly developed microbiotic soil crust communities at both sites. Terricolous lichens were restricted to surface depressions, areas adjacent to ephemeral watercourses, and the north aspect of shrubs. Corticolous lichens at the two sites were generally restricted to the decorticated bark of two desert shrubs (*Coleogyne ramosissima* and *Larrea tridentata).* The central or basal portion of larger more mature individual shrubs was the most common habitat for corticolous lichens. Similar distribution patterns for desert lichen communities have been reported for the Sonoran Desert (Fink 1909).

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PALAEOGLOMUS GRAYI FROM THE ORDOVICIAN

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ABSTRACT

We report structure and properties of fossil hyphae and spores from the Ordovician Guttenberg formation of Wisconsin. The fossils strongly resemble present-day arbuscular mycorrhizal fungi (Glomales) and are described as *Palaeoglomus grayi* gen. et spec. nov.

Key words: fossils, arbuscular mycorrhiza, earliest fungi

INTRODUCTION

Arbuscular endomycorrhiza (AM) is ubiquitous in the vast majority of extant land plants. The fungal symbionts of the AM symbiosis are currently placed in the order Glomales in the Zygomycetes. It has long been hypothesized that AM fungi were present when the first land plants colonized terrestrial environments (Pirozynski & Malloch 1975). Arbuscules and spores from the Rhynie chert (Devonian, 400 Myr) provide direct evidence that an association between primitive vascular plants and arbuscular mycorrhizal fungi existed at that time (Remy et al 1994; Taylor et al 1995), although it is not clear whether it was mutualistic. This was supported by molecular clock studies of rDNA sequences estimating that Glomales originated 462-353 Myr ago (Simon et al 1993).

Recently, glomalean fungi were reported from the Ordovician (455-460 Myr, Redecker et al 2000). These fossil findings are in good agreement with molecular data, showing that some ancestral clades of the Glomales diverged earlier than previously known and suggesting an earlier origin of the Glomales and the Asco/Basidiomycete clade (Berbee and Taylor 2000; Redecker et al 2000).

The earliest macrofossils of early land plants were found in Silurian strata. Spores and cellular scraps interpreted as sporangial epidermis (Kroken et al 1996), but often described as "cuticle", currently are the only evidence of Ordovician land flora (Graham 1993). These microfossils are indicative of Ordovician plants on the bryophyte grade which may not have been preserved as macrofossils. However, fossil plants with hepatic characters producing similar spores have been reported from the Devonian (Edwards et al 1995).

The presence of glomalean fungi in the Ordovician and their well-documented ability to form associations with today's liverworts and hornworts (Schüßler 2000; Read et al 2000), suggest that the Ordovician fungi may have been associated with bryophytes at that time.

In this article we report details of the morphology of the glomalean spores and hyphae from the Ordovician and describe the new species, *Palaeoglomus grayi.*

MATERIALS AND METHODS

Site.--The fossils were recovered from dolomitic rock sampled from an outcrop on Country Highway P site, Dane County, Wisconsin, USA, 43°00'33'' N 89°44'01'' W. The outcrop originates from the Ordovician (Caradoc), Guttenberg formation, Galena group, Decorah subgroup, and were formed approximately 450 to 460 million years ago (Sloan 1987). To avoid contamination by modern organisms, 50 cm of the outcrop were removed with a sledgehammer prior to sampling. Samples were taken from the middle of the outcrop.

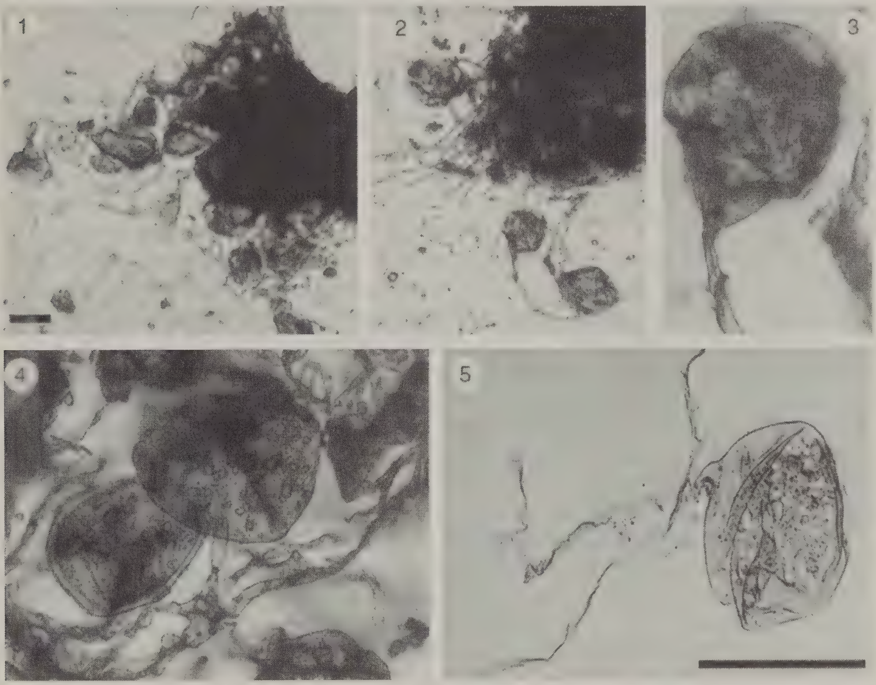
Extraction.--The fossils were extracted from the dolomite in concentrated HCl. Sediment and acid from the first acid bath were discarded to further eliminate contamination. The sediment from the second bath and any remaining rock were examined under a dissecting microscope to collect organic material.

Microscopy.--Specimens were examined under a compound microscope equipped with an Image Explorer System (Hitachi Genetic Systems, Alameda, CA). The material was in air under a microscope cover slip with the exception of the specimen in Fig. 5, which was mounted in polyvinyl alcohol lactoglycerol.

RESULTS

Figs. 1 and 2 show overviews of the Ordovician fossil material. Details of spores and hyphae are depicted in Figs. 3 to 5 from the present paper and in Figs. 1 A to C and E to G of Redecker et al. (2000). Fig. 1 depicts the same specimen as Fig. 1E in that article, but the image was obtained using different microscopic techniques.

The fossil spores and hyphae are of brownish colour. The spores are flattened and deformed and the walls formed folds, similar to extant glomalean fungal spores when subjected to pressure. No wall layers are discernible, which are used for distinguishing species in extant Glomales. The thickness of the wall of the specimen in Fig. 1 is approximately 1 µm. In some spores a second inner layer is visible (Fig.4, left spore) that may have separated from the outer or may be the result of a new spore formed within a dead older spore. Many spores are entangled in hyphae so that it is difficult to distinguish hyphal connections from hyphae attached to the spore surface. However, all spores that were found free had a single hyphal attachment that persisted. This attachment associates the Ordovician spores with modern *Glomus* type spores. Other extant spore types in the Glomales typically do not retain the hyphal attachment that has a "sporiferous saccule" (Acaulosporaceae type) or have an attachment with a "bulbous suspensor" (Gigasporaceae type)



Figs. 1-5: 1. and 2.: Overviews of hyphae and spores of *Palaeoglomus grayi* from the holotype. 3. and 4.: Details of hyphae and spores from the holotype. 5. Spore detail from the paratype. Size bars are 50 µm.

TAXONOMY

Palaeoglomus grayi D. Redecker, Kodner et L. E. Graham, gen. et sp. nov.

Hyphae aseptate, 3 to 5 µm wide, often knobby, occasionally branching with T- and H-shaped junctions. Spores singly and terminally borne, or in loose clusters, globose to subglobose, diameter 40 to 95 µm, wall apparently single-layered; occasionally a second, separate layer visible enclosed within the spore. Spores retaining subtending hypha. Subtending hyphae cylindrical, slightly flared or recurved, continuous with wall of spore. No specialized structures for spore formation visible.

HOLOTYPE. Specimens in slide UCMP 151983 in the University of California Museum of Paleontology collection, Berkeley, USA, including specimens shown in Figs. 1, 2, 3 and 4 in this paper and Figs. 1B, C, F, and G in the article by Redecker et al (2000).

PARATYPE. Specimen in slide UCMP 151984, shown in Fig. 5 (this paper) and Fig.1E in Redecker et al. (2000).

Type locality. Country Highway P site, Dane County, Wisconsin, USA.

Age. Mid-Ordovician.

Stratigraphic position. Caradocian

Etymology. The generic name refers to the similarity with the type of spores produced, among others, by extant AM fungi from the genus *Glomus*. The epithet was chosen in honor of the eminent palaeobotanist Jane Gray, author of pioneering studies on early land plants and fungi.

DISCUSSION

The fossil history of glomalean fungi has been extensively reviewed by Pirozynski and Dalpé (1989). Since that time, several important new findings were reported, among those arbuscules in the Devonian Rhynie Chert (Remy et al 1994; Taylor et al 1995), which are the earliest direct evidence for an association between plants and glomalean fungi. These fungi inhabiting the axes of *Aglaophyton major*, an enigmatic plant intermediate between bryophytes and early vascular plants, formed spores with multilayered walls similar to today's *Glomus*. Taylor et al (1995) named this fungus *Glomites rhyniensis*. Similar spores and hyphae had already been found by Kidston and Lang (1921) in various plant species from that site. In their groundbreaking account of the fungi from the Rhynie Chert, Kidston and Lang reported other fungi in those plant tissues, some of them with septate hyphae. In contrast to the Ordovician fossils, the Rhynie Chert specimens are silicified and were described from thin sections of the rock.

Taylor et al (1995) based their taxonomic diagnosis of *Glomites* to a large extent on the morphology of arbuscules and other intraradical structures. These characters were later used to differentiate the genus from *Gigasporites*, another fossil glomalean genus from the Triassic (Phipps and Taylor 1996).

Spores of *Gigasporites* are not yet known. Because arbuscules and multilayered walls are unknown for the Ordovician fossils, it is not possible to assign them to *Glomites*.

The genus *Palaeomyces* was established by Renault (1896) for fungi from the Carboniferous. Kidston and Lang (1921) used *Palaeomyces* as a genus for all types of fungi with uncertain taxonomic position. They placed Glomales-like fungi into *Palaeomyces*, as well as apparently saprophytic fungi. Therefore it is not appropriate to add the Ordovician fungi presented here to that genus, considering their compelling affiliation with the Glomales. It is more accurate to establish the new genus *Palaeoglomus* for these fungi, based on the morphology of their hyphae and spores.

As discussed previously (Redecker et al 2000), more wall layers might have been originally present in the organisms forming the fossils. Recent studies using molecular sequence data have shown that the *Glomus* spore type is formed by at least four distantly related lineages (*Glomus, Paraglomus, Archaeospora* and *Geosiphon*) within the glomalean clade. Thus, even if wall layers were present, it would not have been feasible to assign the fossil organisms to one of those genera.

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MUSCODOR VITIGENUS ANAM. SP. NOV., AN ENDOPHYTE FROM PAULLINIA PAULLINIOIDES

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ABSTRACT

Muscodor vitigenus, anam. sp. nov., is described as a deuteromycetous (mycelia sterilia) endophytic species of *Paullinia paullinioides*, a liana, bearing a genetic relatedness to the ascomycetous group *Xylaria*. No fruiting bodies or spores have been observed. The hyphae (0.71-2.14 μm dia) frequently intertwine to form stalk-like strands (9.1-145.5 μm dia) that branch as well as form other intricate structures such as perfectly coiled loops (62 μm dia). Often, a matrix substance forms between the hyphae. The species is related to *Xylariaceae* by virtue of 96% homology of its 18S rDNA (1815 bp) to representative members of this group. In addition, ITS1, 5.8S, and ITS2 sequences (595 bp) of *M. vitigenus* showed close relatedness to several *Xylaria* spp. including *X. enteroleuca*, and *X. arbuscula* at the 90% level. High similarities of 18S rDNA and ITS1, 5.8S, and ITS2 rDNA and phylogenetic analysis showed that *M. vitigenus* is taxonomically related to *Muscodor albus* and *Muscodor roseus*. While *M. albus* and *M. roseus* produce a musty odor resulting from a mixture of volatile compounds, including naphthalene derivatives, *M. vitigenus* produces the scent of moth balls which is naphthalene.

Keywords: *Xylaria*, naphthalene, endophyte, mycelia sterilia, 18S rDNA

INTRODUCTION

Plants seem to be serving as a reservoir of untold numbers of organisms known as endophytes (Bacon and White, 2000). By definition, these microorganisms (mostly fungi and bacteria) live in the interstitial spaces of the living tissues of the plants and cause no apparent harm to the host (Azevedo et al., 2000). Because the world's rainforests house a vastly diverse array of plants, it seems to be a likely source of an even greater assembly of endophytic organisms. It seems that endophytes may be a source of natural products that have biological activities that could be applied to medicine, agriculture, and/or industry. Unfortunately, many endophytes that have been isolated are ignored because a significant percentage of them bear no fruiting structures, either sexual or asexual, making identification by standard methods impossible (Bayman et al., 1997).

The classical systematic approach to fungal taxonomy uses solely morphological traits, as characters, which are used to classify an organism into its clade as well as assigning it a binomial. This system cannot be applied successfully to organisms lacking spore production because of the absence of necessary phenotypic data. "Phylogenetic Character Mapping" surmounts this obstacle to some degree because it combines available morphological information with molecular data (Mitchell et al., 1995; Guarro et al., 1999; Taylor et al., 1999). Using genetic sequences, the similarities and differences between organisms are also coded as a set of characters; in this case the sequence arrangements of the four nucleotides. Paired with statistical support, the taxonomic relationship of organisms can then be characterized on the basis of a shared possession of uniquely derived nucleotide distribution. The rDNA genes are frequently targeted for fungal taxonomy (Bruns et al., 1991; Guarro et al., 1999; Mitchell et al., 1995) because they are highly conserved regions of molecular information, they are found in all organisms with a common evolutionary origin, and they represent a non-protein-coding region. The 18S rDNA is useful for identifying relationships above the generic level while the internal transcribed spacer regions are useful for discerning relationships at the species level. The naming of fungi using DNA sequence information can thus be achieved under the present code of Botanical Nomenclature (Reynolds and Taylor, 1993).

Due to the extreme diversity of endophytic microbes in rainforest plants, it has been of interest to isolate and characterize some of these obscure organisms, especially those having unusual biological characteristics. Recently, for instance, we have described a novel set of endophytic fungi that do not posses fruiting structures or spores and have been characterized via molecular biological techniques. One of these fungi, *Muscodor albus* (Worapong et al., 2001), was isolated from the internal tissues of a cinnamon tree branch, *Cinnamomum zeylanicum*, growing in Honduras. Another two isolates of a related species, *Muscodor roseus* (Worapong et al., 2002), were acquired from two separate plant species native to Australia, *Erythophelum chlorostachys* and *Grevillea pteridifolia*. Binomials were established for these fungi using the molecular methods of Phylogenetic Character Mapping; 18S rDNA as well as ITS1, 5.8S, and ITS2 sequences were determined using PCR techniques and then submitted to GenBank for comparison to the other fungal sequences. Ultimately, it was shown that these isolates were related but not identical to the group *Xylaria*, and were related to each other at the genus level.

These isolates of the *Muscodor* spp. display the unique ability to produce gaseous volatiles that act as tremendously efficient antimicrobials, killing a wide spectrum of plant pathogens as well as microorganisms that are pathogenic to humans (Strobel et al., 2001). Because of the great potential for the functional importance of these organisms, it was deemed important to find other isolates of this group in nature. The majority of organisms exposed to the volatiles of the *Muscodor* spp. were severely inhibited and/or killed though they can grow in each other's atmosphere without any detrimental effects. Because of this, the *Muscodor* isolates were used as a selection tool in culture to find other related fungi. Using this technique, another volatile producing endophyte, designated P-15, was isolated from a flowering vine, *Paullinia paullinioides*, native to Peru.

The isolate P-15 culture exhibited many of the characteristics common to the existing *Muscodor* isolates, specifically a lack of fruiting structures in culture and lack of spore production. All *Muscodor* spp. share the features of growing slowly, having a felt-like mycelium, and having a distinctive odor. However, there are cultural, chemical, and molecular differences between them. Most significantly, gas chromatography and mass spectroscopy (GC/MS) helped to identify 26-28 different active compounds in both *M. albus* and *M. roseus*, including naphthalene derivatives (Strobel et al., 2001). When the atmosphere created by isolate P-15 was subjected to GC/MS, there were significantly fewer compounds, the most prominent being naphthalene. Thus, the intent of this report is to describe this novel fungus based on its unique characteristics as well as to employ morphological information and molecular data to illustrate its evolutionary relationship with other fungi and to give it a scientific binomial. The proposed name for this fungus is *Muscodor vitigenus*.

MATERIALS AND METHODS

Fungal Isolation

Several small pieces of *P. paullinioides* Radlk. were removed from a plant growing in an area near the Lake Sandoval at 12° 36' 27" N, 69° 01' 58" W and immediately transported to Montana State University for processing in May of 2001. In order to select fungi that may produce volatile antibiotics or other biologically active substances, a selection system was employed that used a specially prepared Petri plate. Namely, one half of the plate contained water agar (WA) and the other half contained potato dextrose agar (PDA). A 2 cm wide slice of agar was cut from the entire midsection thus physically separating the two types of agar. *M. albus* or *M. roseus* were inoculated onto the PDA in the plate and allowed to grow for two weeks. These organisms make volatile antimicrobial gases (Strobel et al., 2001). Small pieces obtained from the internal tissues of the plant stem, from which endophytes were to be isolated, were then placed on the WA. The plates were sealed with two layers of parafilm and the plant pieces were inspected for endophytic emergence after 7- 10 days. Organisms that developed from the plant material in the environment of the volatile gases are resistant to the *Muscodor* spp. We have found that the *Muscodor* spp. are able to grow in the toxic environment produced by one and other with no apparent inhibition; this was the principle reason that this method was used in the fungal isolation (Worapong et al., 2001). The fungi growing in this environment could possibly be related to the *Muscodor* spp. and/or produce volatile compounds. Most commonly, *Pestalotiopsis* spp. and *Xylaria* spp. were isolated using this procedure. One fungal isolate that was recovered from *P. paullinioides* demonstrated gas-production and it was designated "P-15." This isolate produced a whitish, dense, felt-like mycelium on PDA and other media that bore great similarity to the other gas-producing isolates of the *Muscodor* spp. It exuded the pungent odor of naphthalene. The fungus was deuteromycetous and produced no spores.

Scanning Electron Microscopy

Scanning electron microscopy was preformed on isolate P-15 by placing agar pieces as well as host plant pieces supporting fungal growth into distilled water with Triton X 100, a wetting agent, and aspirated for 5 min (Strobel et al., 1996). The fungal preparation was then placed into 2% gluteraldehyde in 0.1 M sodium cacodylate buffer (pH 7.2-7.4) and left overnight. The next day they were washed in six 15 min changes in water buffer, followed by three 15 min changes in 10% ethanol, four 15 min changes in 30% ethanol, five 15 min changes in 50% ethanol, and then they were left in 70% ethanol for two days. They were then rinsed in five 15 min changes in 100% ethanol. The dehydration process was executed slowly to avoid hyphal shriveling which is associated with rapid dehydration. Ultimately, the fungal material was critically point dried, gold sputter coated, and examined with a JEOL 6100 scanning electron microscope (SEM).

Fungal Growth and Storage

Isolate P-15 was grown on a wide variety of media to achieve maximum maturation and production of secondary metabolites. This assortment included PDA, Tryptic Soy Broth Agar (TSBA), Corn Meal Agar (CMA), Malt Agar (MA), and WA (Difco Laboratories, Detroit, Michigan). Customized media was also prepared including natural potato dextrose agar (PDAN), V-8 agar, sweet potato agar, and cinnamon agar. 1 L of PDAN was made with 10 g potato starch, 15 g sucrose, 15 g agar, and distilled water. 1 L of V-8 agar was made with 88 ml V-8 juice, 1 g calcium carbonate, 10 g agar, and distilled water. 1 L of sweet potato agar was made with 20 g dry tapioca, one 16 oz can of sweet potatoes, 20 g agar, and distilled water. 1 L of cinnamon agar was made with 20 g mashed bananas, 100 ml coconut milk, 0.5 ml wheat germ oil, 3 g ground cinnamon, 12 g agar, and distilled water. The fungus was also inoculated onto Petri plates containing these various agars as well as individual samples of small shavings (.05 g) of White Oak (*Quercus alba*), Carnation (*Dianthus*), Pecan (*Carya*), Japanese Yew (*Cuspus cuspidata*), as well as bark pieces from *P. paullinioides*, each on WA, PDA, or PDAN , in order to encourage spore production.

In order to determine the best method to store isolate P-15, several conditions were tested. The fungus was grown on sterilized Whatman No. 1 filter papers placed on PDA in a Petri plate. The fungus was inoculated onto the center of the filter paper disc as an agar plug and allowed to incubate at 22° C for 14 days. The paper disc was removed and placed in a laminar flow hood under sterile conditions until the paper was dry. The paper disc was cut into small sections and stored in a sterile vial at -70° C. The fungus was also grown on PDA for 14 days and cut into small agar bits, placed in sterile distilled water, and stored at 4° C. Finally, the fungus was grown on PDA until hyphal growth was observed and then sterile oats or bark pieces of *P. paullinioides* were placed on top of the growth. After 14 days the plant pieces were covered with the fungal growth and they were placed in 15% glycerol and stored at both 4° C and –70° C. In each test, fungal viability was determined by placing the hyphal fragments onto PDA and inspecting for growth after 3-4 days. Maintenance of fungal gas-production was determined by analyzing volatiles produced by the fungus using GC/MS procedures (Strobel et al., 2001).

Fungal DNA Isolation

For DNA isolation, P-15 was grown on PDA in a 9 cm Petri plate for 14 days at 23° C. The mycelium was scraped directly from the surface of the agar culture and weighed. White quartz sand (3 g per g of tissue), phenol/chloroform/isoamyl alcohol 25:24:1 (0.5 ml per g of tissue), and extraction buffer (0.4 ml per g of sand) were added to the tissue in a mortar and ground vigorously for 30 sec with a pestle. Extraction buffer was again added (2 ml per 0.5 g of starting tissue) as well as more of the phenol/chloroform/isoamyl alcohol mixture (1 ml per 0.5 g of starting tissue). After mixing well, the solution was transferred into several microfuge tubes and centrifuged at 16,000 g for 5 min at 25° C. The aqueous phase was transferred to a new tube and mixed with 0.6 vol. of isopropanol. The samples were incubated at 25° C for 10 min and then centrifuged at 4° C for 15 min at 16,000 g to recover precipitate. The pellets were rinsed with 95% ethanol and then air dried. The pellets were then resuspended in 340 μl TE containing RNase A (20 μg/ml). The samples were incubated at 37° C for 30 min. After incubation 0.3 ml of the phenol/chloroform/isoamyl alcohol mixture was added to the samples. The samples were mixed and centrifuged at 4° C for 2 min. The supernatant liquid was transferred to a new tube and 1/2 vol of 7.5 M ammonium acetate and 2.5 vol of 100% ethanol were added. The samples were incubated for 30 min at –20° C and then centrifuged at 4° C for 15 min at 16,000 g. The pelleted DNA was rinsed with 70% ethanol, air dried, and resuspended in 100 μl ddH_20. Agarose gel electrophoresis and a UV spectrophotograph were then used (Weiland).

Amplification of 18S ribosomal DNA

Partial nucleotide base pair fragments of the 18S rDNA gene from isolate P-15 were amplified via the polymerase chain reaction (PCR) as a single fragment with the primer NS1 (5' GTA-GTC-ATA-TGC-TTG-TCT-C 3') and NS8 (5' TCC-GCA-GGT-TCA-CCT-ACG-GA 3'). PCR was performed in a 25 μl reaction vial containing 0.1 μg genomic DNA, 10 mM each primer, 3 mM four dNTPs and 0.5 μg *Taq* polymerase (Fisher) in 10x *Taq* Buffer A (Fisher) containing 500 mM potassium chloride, 15 mM magnesium chloride, 100 mM Tris-HCl (pH 9.0 at 25° C). Amplification began with 95° C for 5 min followed by 34 cycles of 40 sec at 95° C, 40 sec at 45° C, and 40 sec at 72° C followed by 5 min at 72° C.

Amplification of Internal Transcribed Space sequences (ITS) and 5.8S rDNA

The ITS regions of isolate P-15 were amplified using PCR and the universal ITS primers ITS1 (5' TCC-GTA-GGT-GAA-CCT-GCG-G 3') and ITS4 (5' TCC-TCC-GCT-TAT-TGA-TAT-GC 3') (White *et al.* 1990). PCR was preformed the same way as it was for the 18S rDNA except for the annealing temperature which was 60° C. The PCR products were purified and desalted using the QIAquick PCR purification kit (Qiagen).

Cloning

The PCR product was cloned into a pDrive TA vector (Qiagen PCR cloning kit) according to manufacturer's instructions.

Transformation and Extraction

Preparation of competent cells was preformed by the CCNB80 method. DH5α *E.coli* grown to 0.3 OD at 595 nm. The culture was chilled on ice for 10 min. The cells were then pelleted by centrifugation for 10 min at 4° C at 5000 rpm. The pellet was resuspended in 1/3 of the original volume of cold CCNB80 (for L 10 ml 1m potassium acetate, 2 g magnesium chloride, 4 g manganese chloride, 11.8 g calcium chloride, 100 ml glycerol). The resuspension was left on ice for 20 min, repelleted, and resuspended in CCNB80 (1/12 the original volume). The resuspension was left on ice for 10 minutes. The suspension was divided into 200 µl aliquot Eppendorf vials and immediately frozen in -80° C. The DNA transformation into the cells was preformed according to Sambrook et al. (1989). The transformed cells were plated on LB agar with a selective antibiotic, kanomycin sulfate (Sigma), in the presence of IPTG and X-gal for blue/white selection. White single colonies were grown in LB broth and DNA was extracted by using a Perfectprep Plasmid Mini (Eppendorf) according to manufacturer's instructions. Presence of the insert was confirmed by DNA digestion with the EcoRI restriction enzyme (Promega).

Cycle Sequencing 18S rDNA, ITS Regions and 5.8S rDNA

The plasmid inserts were sequenced by the Plant-Microbe Genomics Facility at Ohio State University using an Applied Biosystems 3700 DNA Analyzer and BigDye™ cycle sequencing terminator chemistry.

Table 1. Primers used for determining 18S rDNA and ITS and 5.8S nucleotide sequences of *M. vitigenus*

Primers	Sequences from 5' to 3'
NS1	5' GTA GTC ATA TGC TTG TCT C 3'
NS8	5' TCC GCA GGT TCA CCT ACG GA 3'
ITS1	5' TCC GTA GGT GAA CCT GCG G 3'
ITS4	5' TCC TCC GCT TAT TGA TAT GC 3'
SP6	5' CAT TTA GGT GAA CAC TAT AG 3'
T7	5' GTA ATA CGA CTC ACT ATA G 3'
2SP61	5' CGT GTG GGT CTA TTT TGG TGG G 3'
2T71	5' CGA TCC CCT ACT TTC GTT CCT G 3'

Searching and Comparison 18S rDNA and ITS 1-2 sequences

Both 18S rDNA and ITS1-2 sequences of culture collection P-15, also known as *Muscodor vitigenus*, were submitted to GenBank with serial numbers. These sequences were also searched and compared with other fungal sequences under Blast 2.1 and a search of NCBI at the web site http://www.ncbi.nlm.nih.gov/BLAST. Comparison and alignment sequences were done by using Standard nucleotide-nucleotide BLAST [blastn] at http://www.ncbi.nlm.nih.gov/BLAST and manually aligned afterwards.

RESULTS AND DISCUSSION

Fungal Taxonomy

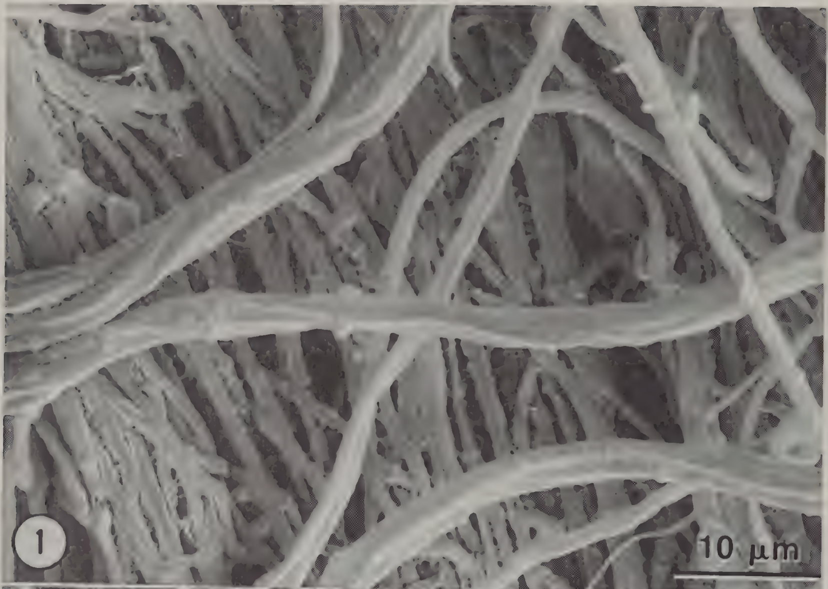
Muscodor vitigenus Daisy, Strobel, Ezra, and W.M. Hess, anam. sp. nov. (Figs. 1-4)

***Fungus** in natura cum Paullinia paullinioide consociatus et est deuteromycete myceliis sterilibus pertinens. **Coloniae fungales** albidae et immutatae remanentes in mediis omnibus temptatis, folia specierum aliquot plantarum et scobes ligni specierum aliquot arborum includentes, P. paullinioides inclusa. Sporae vel corpora fructificantia sub statibus ullis non observata. **Mycelium** in PDA in 3-4 hebdomadibus patellam tegens et odorem blattigloborum producens. Mycelium vetius (4-6 hebdomates aetate) sectiones cuneiformes erumpentes vulgo formans, quas loco inoculationis radiantibus, has praesertim manifestas quum materia plantarum in mediis adest. **Hyphae** (0.71-2.14 µm dia.) vulgo ramificantes et convolventes, fila stipiformia (9.1-145.5 µm dia.) et spiras perfectas (62 µm dia.) formantes.*

The **fungus** in nature is associated with *P. paullinoides* and is a deuteromycete belonging to mycelia sterilia. **Fungal colonies** whitish on all media tested, including growth on leaves of several plant species and on wood shavings of several tree species, including those of *P. paullinoides*. This characteristic remains unchanged. No spores or fruiting bodies were observed under any conditions. **Mycelium** on PDA covers the plate in 3-4 weeks and produces an odor of moth balls. Older mycelium (4-6 weeks) commonly display erumpent wedge shaped segments that spread from the original site of inoculation, this is especially apparent when plant material is present on the media. **Hyphae** (0.71-2.14 µm) commonly growing by branching, intertwining, and forming stalk-like strands (9.1-145.5 µm) and perfect coils (62 µm).

The telomorph of this fungus may be found in *Xylariaceae*, based on the 96% homology of the 18S rDNA gene sequence (1815 bp) between *M. vitigenus* and the family *Xylariaceae* in the GenBank database. The molecular data from the 18S rDNA gene sequences of *M. vitigenus* show a 99% homology with *M. albus* and *M. roseus*. The ITS1-2 rDNA sequences of *M. vitigenus* show a 95% homology with *M. albus and M. roseus*. This supports a new species division in the genus *Muscodor- M. vitigenus*.

Holotype: Endophytic on *P. paullinioides*. Collections were made in the Manu rainforest of Peru near Lake Sandoval. The holotype comes from only one *P. paullinioides* vine, collected in September 2001 by Gary and Suzan Strobel, and W.M Hess. Dried culture deposited in the Montana State herbarium (MONT) as *Muscodor vitigenus* isolate P-15, 03/27/02. A living culture is also deposited as *Muscodor vitigenus* in the living MSU mycological collection as **acquisition-2116**, 03/27/02. Both 18S rDNA and ITS1 and ITS2 sequences of *M. vitigenus* (P-15) have been submitted to GenBank with the assigned serial numbers **AY100023** and **AY 100022**, respectively.



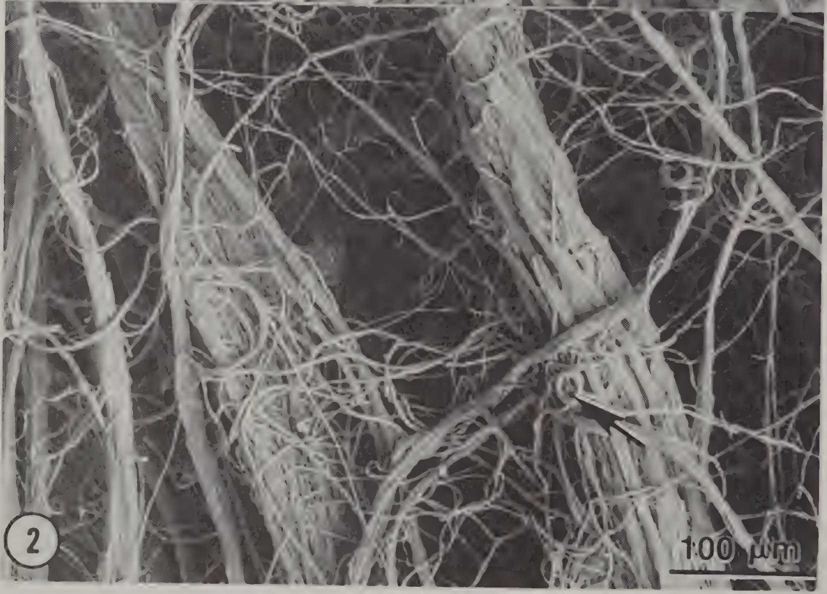
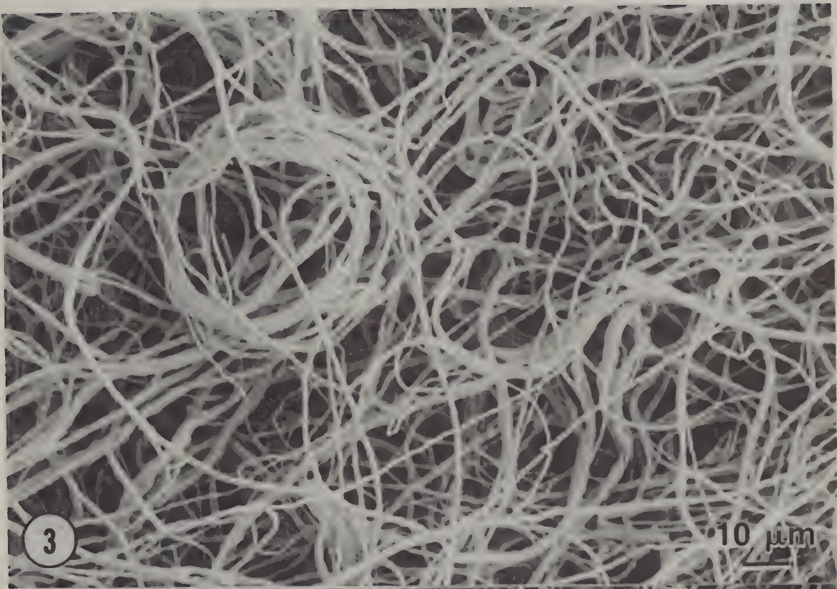


Fig. 1. Scanning electron micrograph of hyphae and mycelium of *M. vitigenus* growing on PDA. Please note the branching of individual hyphae from rope-like strands.

Fig. 2. Scanning electron micrograph showing the twisted cable-like strands of mycelium. Please note the example of a nearly perfect coil structure (arrow).



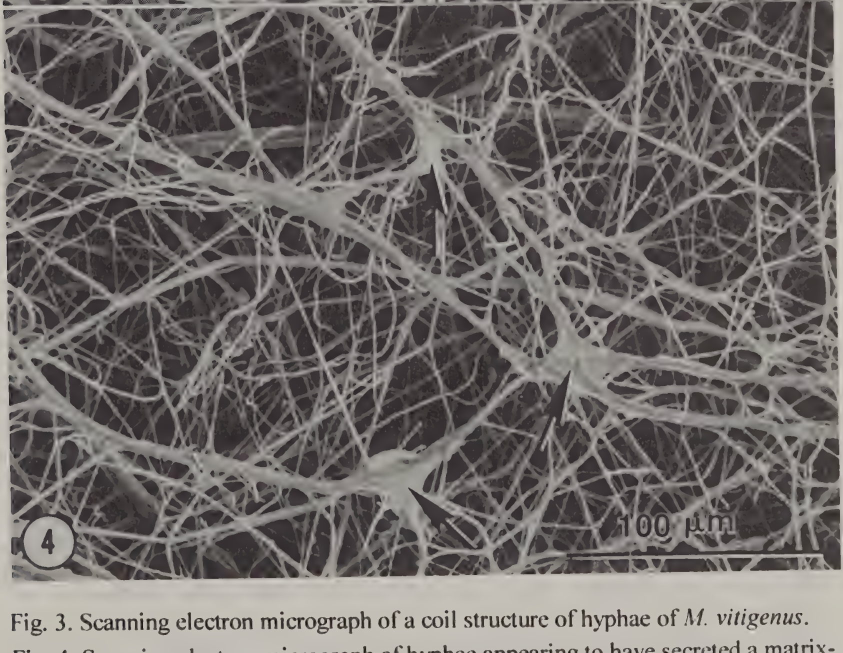


Fig. 3. Scanning electron micrograph of a coil structure of hyphae of *M. vitigenus*.

Fig. 4. Scanning electron micrograph of hyphae appearing to have secreted a matrix-like substance (arrows).

Telomorph: Unknown

Etymology: The genus name, *Muscodor*, is taken from the Latin word which means musty. This is consistent with the quality of the odor produced by the first three isolates of the genus. The species epithet is – *vitigenus*, a Latin word meaning "produced from the vine," *P. paullinioides*, the plant from which *M. vitigenus* was isolated, is a vine.

Molecular Biology of *Muscodor vitigenus*

The partial sequences of 18S rDNA, ITS1, 5.8S, and ITS2 have been demonstrated to be highly conserved regions of DNA and therefore very useful in the classification of organisms. These molecularly distinguishing partial sequences of *M. vitigenus* were obtained and compared with the data in GenBank. After searching the 18S rDNA sequences, 1815 bp of *M. vitigenus* were subjected to an advanced blast search. The results showed 99, 99, 97, 96, 96, and 96% identities with 1146 bp of *M. albus* (AF324337), 1146 bp of *M. roseus* (AY034664), 1717 bp *Poronia punctata* (AF064052), 1771 bp of *Ascotricha chartarum* (AB048283), 1772 bp of *Xylaria* sp. 1FOH-12237 (AB048280), and 1770 bp of *Surculiseries rugispora* (AB048279), respectively.

Comparative analysis of the partial ITS 1&2 and 5.8S rDNA sequences of *M. vitigenus* hit ITS 1 and 2 of *M. albus* (AF324336), *M. roseus* (AY034664*), X. enteroleuca* CBS 651.89 (AF163033), *X. arbuscula* CBS 452.63 (AF163029), and *Hypoxylon fragiforme* (HFR246218) at 95, 95, 90, 90, and 91% homologies, respectively. No total identities were found; the data from the 18S rDNA as well as the ITS 1&2 and 5.8S rDNA provides molecular justification that *M. vitigenus* should be considered its own species.

Fungal Biology

The fungus produced a white mycelium on the wood chips of numerous plant species, including the bark of *P. paullinioides*, as well as on water based media. No fruiting structures or spores of any kind have been found under any lab conditions (Fig. 1-4). Hyphae tend to intertwine to form rope-like stalks from which smaller cables or individual hyphae emerge and branch (Fig. 3). Other species of *Muscodor* have this tendency (Worapong et al., 2001, Worapong et al., 2002). On occasion, the fungus also produces a matrix-like or polymeric material that seems to cover and join hyphae (Fig.4). *M. vitigenus* could be best stored (at least 8 months) when originally grown on filter paper and placed at -70° C. It also remained viable, but to a lesser degree, when stored in glycerol/distilled water at -70° C. The fungus consistently produced naphthalene on PDAN with pieces of *P. paullinioides* present. The fungus also produced naphthalene, but inconsistently on PDAN as well as on PDA with no pieces of plant material. The moth ball odor produced by the fungus becomes noticeable after about 1 week and seems to increase with time.

Chemical characters between the *Muscodor* spp. vary largely, especially those of *M. vitigenus*. While naphthalene derivatives are included among the 26-28 different compounds (alcohols, esters, ketones, acids, and lipids) produced by *M. albus* and *M. roseus* (Strobel et. al., 2001), *M. vitigenus* produces almost solely naphthalene (Daisy, Strobel, Sears, Runyon, and Weaver, unpublished). This finding lends chemical support to the argument that *M. vitigenus* is taxonomically distinct from *M. albus* and *M. roseus*. The gases produced by *M. vitigenus* also differ from the rest of the *Muscodor* spp. because they do not seem to be notably antimicrobial. The fact that naphthalene is produced by *M. vitigenus* does, however, qualify it for further investigation for other potential agricultural uses in biological control methods.

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GLOMUS KERGUELENSE SP. NOV., A NEW GLOMALES SPECIES FROM SUB-ANTARCTIC

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ABSTRACT

Glomus kerguelense sp. nov. was isolated from a gravelly mineral soil at Kerguelen Islands, in association with the rhizosphere of introduced *Agrostis stolonifera*, Poaceae. This golden yellow spored species is distinguished from other Glomeraceae species by the granular ornamentation of the interior surface of the inner spore wall layer, and by a spongy zone gradually developed within the middle spore wall layer. The isolate differentiated vesicles and arbuscles inside *Allium porrum* roots and sporulated profusely in pot cultures. *Glomus kerguelense* is, with *G. antarcticum*, the second Glomales species described originally from the Antarctic region.

Glomus kerguelense sp. nov. a été isolé d'un sol minéral graveleux des Îles Kerguelen, dans la rhizosphère d'une Poacées introduite, *Agrostis stolonifera.* L'espèce aux spores jaune doré se distingue d'autres espèces de Gloméracées par une ornementation granulaire à la surface intérieure de la paroi interne et par une zone spongieuse graduellement différenciée dans la paroi médiane. L'isolat cultivé en pots différencie avec *Allium porrum* des vésicules et des arbuscules intraracinaires ainsi que des spores en abondance. *Glomus kerguelense* constitue, avec *G. antarcticum*, la seconde espèce de Glomérales décrite des régions antarctiques.

KEYWORDS : Arbuscular mycorrhizal fungus, Glomales.

INTRODUCTION

Recent field expeditions to Kerguelen Islands supported by the French Polar Institute (IPEV) were performed to study the impact of climatic changes and human activities on the biodiversity of French sub-Antarctic Islands (Frenot et al 2001). Published studies and reports on arbuscular mycorrhizal (AM) symbioses under Antarctic and sub-Antarctic climates have dealt almost exclusively with plant mycorrhizal status (Christie & Nicholson 1983; Smith & Newton 1996; Laursen et al 1996; Strullu et al 1999). Up to now, only one Glomales species, *Glomus antarcticum* Cabello has been originally described from the Antarctic continent, associated with *Deschampsia antarctica* Dev. (Cabello et al 1994). Similarly, only 5 arbuscular mycorrhizal fungal (AMF) species were found sporulating in indigenous Arctic soils within the rhizosphere of *Festuca* species (Dalpé & Aiken 1998), and all other studies have reported plant arbuscular symbiotic associations (Stutz 1972; Kohn & Stasovski 1990; Bledsoe et al 1990; Gardes & Dahlberg 1996).

In the present survey on Kerguelen Islands, an undescribed taxon was found associated with *Agrostis stolonifera* L., an introduced Poaceae with a worldwide distribution. Herein we describe *G. kerguelense* sp. nov., based on juvenile and mature spore morphologies and the ontogenetic sequence of spore wall layer development, supported by ultrastructural observations. Spores are characterized by their inside wall layer ornamentation and a middle spongy wall layer. Mycorrhizal behavior of the new species under greenhouse growing conditions is characterized by an abundant leek root colonization and a high sporulation rate.

MATERIAL AND METHODS

Soil harvesting and inoculum production

Rhizospheric soil samples (20 mL) containing roots sections of *Agrostis stolonifera* were collected from a gravelly mineral soil at Port-aux-Français, Kerguelen Island, Southern Indian Ocean. Soil samples were mixed with calcined clay, Oil-Dri US-special Ty/IIIR particle size average 5 mm (Oil-Dri Company, Chicago, USA) and used as mycorrhizal inoculum. Leek plants (*Allium porrum* L. cv "Alex") were grown on calcined clay watered weekly with a nutrient solution (Plenchette, 1982) and placed in a greenhouse with a controlled environment (20°C/24°C; natural light supplemented high pressure sodium lamps to maintain a day/night period of 14/10h during autumn, winter and early spring. Three growth cycles of 6 months were required to purify mycorrhizal inoculum during which colonized roots were used to reinoculate leek plants.

Spore isolation and microscopic observations

Spores were extracted from the pot culture by wet sieving and decanting techniques (Gerdemann & Nicolson, 1963) prior to vacuum filtering over filter paper *(Whatman #2)*. Spores were then manually isolated under the dissecting microscope and permanently mounted in: 1) PVLG (Polyvinyl, lactic acid, glycerol) media (Omar et al 1979), 2) PVLG : Melzer's reagent (1:1, v/v), and in 3) PVLG : Cotton Blue (0.155 in lactic acid) (1:1,v/v). For better observation of inner wall ornamentation, spores were submitted to a 30 sec. ultrasonic treatment in order to remove remaining soil debris attached to the evanescent outer wall layer. Light microscopy was done under regular light and DIC (differential interference contrast) and color observations referred to the International Culture Collection of Arbuscular and vesicular-arbuscular mycorrhizal Fungi (INVAM) color chart codes. For transmission electron microscopy, (TEM), spores were fixed at 4°C for 18 h in 2.8% glutaraldehyde, 1.5% p-formaldehyde in 0.2M phosphate buffer, washed and centrifuged in 0.1M phosphate buffer followed by double distilled water, postfixed in 2% aqueous osmic acid before dehydration, stained in uranyl acetate, and embedded in LRWhite (London Resin Company Ltd.). Ultrathin sections were mounted on grids and observed under a Zeiss EM902 electron microscope at 80 kv. For scanning electron microscopy (SEM), spores were fixed similarly, coated with gold, and observed under a Zeiss DSM940A digital SEM.

Estimation of root colonization

Root sections were cleaned in water to remove soil debris, cleared in 10% KOH at 90°C for 30 min, rinsed in water, stained in fuchsin acid (0.5%) - lactoglycerol ($H2O$:lactic acid: glycerol, 1:1:1,v/v/v) at 90°C for 15 min, rinsed in water and preserved in lactoglycerol till use . Root colonization levels were estimated using light microscope, 40X objective, using the grid-line intersect methodology (Giovannetti & Mosse, 1980). Root sections were mounted in PVLG for morphological observation under light microscopy.

LATIN DIAGNOSIS

Glomus kerguelense Dalpé & Strullu *sp. nov.* FIGS. 1-2

Sporocarpia ignota. Juveniles sporae, globosae vel subglobosae, 75-162 µm diam., hyalinae ad perpallidae flavidae; maturae sporae luteae, 153-216 µm diam., laeves, faciei externe visae apparenter verrucatae propter interni parietis ornamentatum, singulatim vel aggregatim in solo et abundanter intra radices efformatae; crescentes apici hyphae sustinentis solitariae. Juvenilium tunicae sporarum stratis tribus 3.5-6.2 µm crassae; tunica externa hyalina, 0.6-1.8 µm crassa, laevis, evanescens, mucilagina; stratum secundum, hyalinum ad perpallidum flavidum, 2.4-3.6 µm crassum, laeve, tenuiter laminatum; stratum tertium, hyalinum ad perpallidum flavidum, 0.5-0.8 µm crassum, tenuiter laminatum, praeditum minutas verrucas, 0.2-0.3 µm latas, irregulariter 1.2-1.8 µm distantes. Maturarum tunicae sporarum, stratibus tribus, 6.5-10.8 µm crassae; tunica externa eadem ac juvenilium tunicae sporarum; stratum secundum, luteum, 4.3-6.8 µm crassum, laminatum, formans mature spongiosam *mediam zonam 1.5-1.9 µm crassam ; stratum tertium, aureum, laminatum, 1.6-2.2 µm crassum, verrucatum. Hyphae sustinentes, hyalinae ad aureae, cylindricae vel subinfundibuliformes, 8.5-14 µm crassae, aliquando tumidae, 16-21 µm crassae. Porus sporae curvo septo clausus. Mycorrhizae cum vesiculis et arbusculis formans.*

Sporocarps : unknown.

Spores (Fig 1A-D) globose to subglobose formed singly or in clusters of 3 to 5 spores in soil, and also inside roots between cortical cells; differentiated at the apex of a single cylindrical coenocytic subtending hypha. Juvenile spores yellow (0/10/100/0), 75 - 162 µm in diameter, mature spores yellow (0/40/100/0), 153 - 216 µm in diameter (mean diam. 186.3 µm), smooth surfaced; in water mounting media, most juvenile and some mature spores exhibit a granular appearance due to the inside inner wall rugosity.

Juvenile spore wall (Fig 2 A,D,E) composed of three layers, 3.5 - 6.2 µm total thickness ; layer 1: hyaline, 0.6 - 1.8 µm thick, evanescent, mucilaginous, surface smooth to roughened irregular, sometimes disappearing with spore maturation. Layer 2: hyaline to pale yellow, 2.4–3.6 µm thick, finely laminated under light microscope, surface smooth, wall showing a fibrillar texture of different opacity under TEM, corresponding to the sub-layers developed during subsequent maturation. Layer 3: hyaline to pale yellow, 0.5 - 0.8 µm thick, finely laminated, inside surface ornamented with irregularly spaced wart, 0.2-0.3 µm wide distanced by 1.2 - 1.8 µm, giving by transparency a fine granular texture to the spores under the light microscope. Under TEM, the inner surface ornamentation appearing as a succession of irregular cavities, 1.3-1.5 µm wide. All layers stained with Cotton Blue, facilitating the observation of inside ornamentations; no reaction observed with Melzer's reagent.

Mature spore wall (Fig 2 B,C,F,G) composed of three layers, 6,5 - 10.8 µm total thickness; layer 1: identical to the one of juvenile spores; layer 2: yellow, 4.3 - 6.8 µm thick, laminated, maturing by differentiating a spongy middle zone, 1.5 - 1.9 µm thick sandwiched between an outer (1.2 - 1.6 µm thick) and

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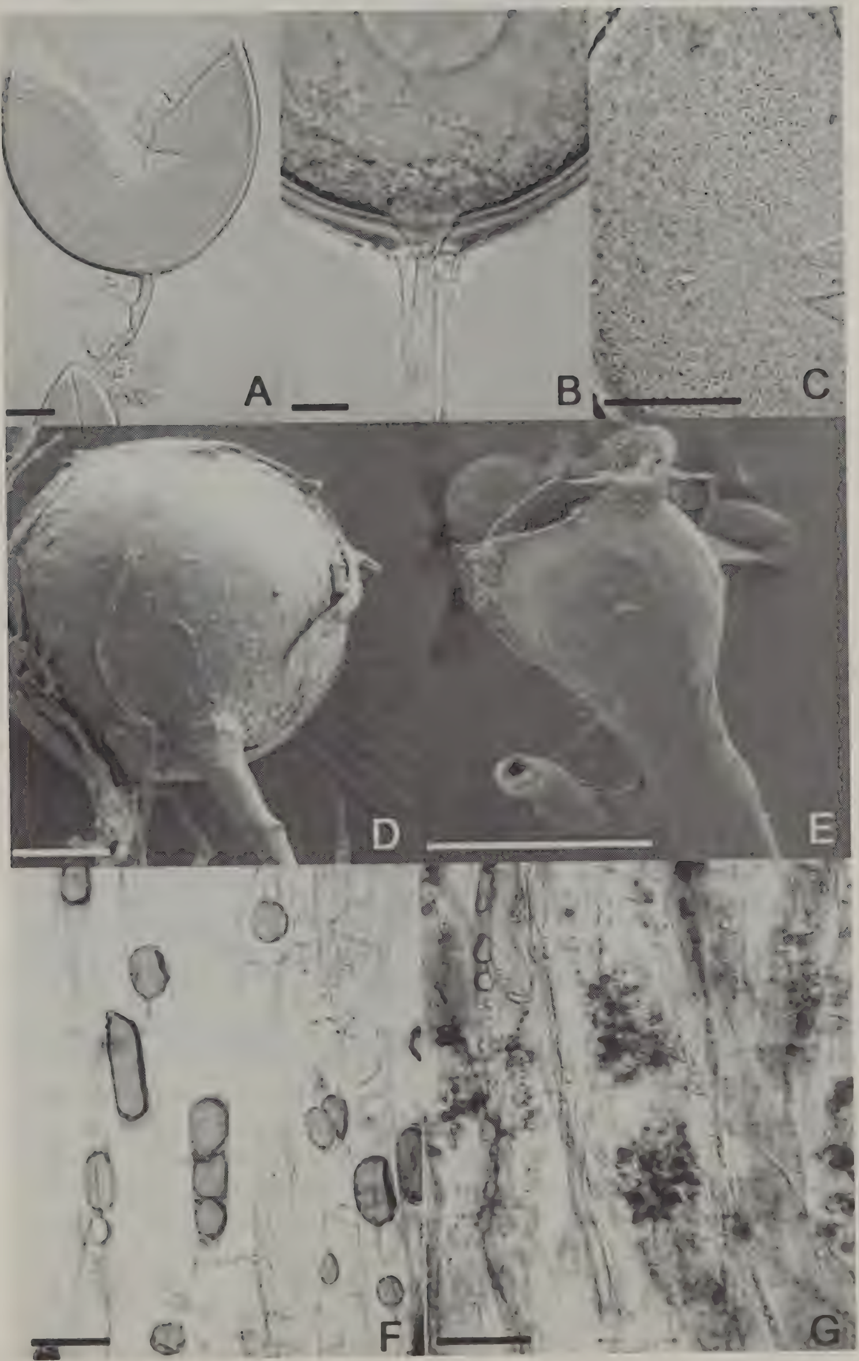
Fig. 1 A-G *Glomus kerguelense* A. Juvenile crushed spore with subtending hyphae; B. Septum at subtending hyphal attachment of a mature spore; C. Spore granular appearance from inside wall; D. Spore and subtending hyphal attachment under SEM; E. Subtending hyphal attachment with lateral peg under SEM; F. Vesicles colonizing leek (*Allium porrum*) roots; G. Arbuscules inside cortical cells of leek colonized roots. (Scale bars = 20 µm)


A
B
C
D
E
F
G

an inner (2.0 - 2.7 µm thick) section; the spongy area made of holes forming reticulations that appeared under light microscopy as a line of wrinkles between two laminated sections and under electron microscopy as a lacunar tissue in between two fibrillous zones; layer 3: golden yellow, 1.6 - 2.2 µm thick, laminated, inner surface covered with fine granulosity disappearing gradually with maturity. Under TEM, this third layer is already detectable in juvenile spores but laminations are not yet strongly contrasted . At spore maturity, all layers react to Cotton Blue and none to Melzer's reagent.

Subtending hyphae (Fig 1 B.D.E), cylindrical to slightly flared with juvenile spores, 8.5 - 14µm wide, sometimes funnel-shaped with mature spores, 16 - 21 µm at the largest diameter. During the spore maturation process, the pore is closed at an early stage by a curved septum formed by the inner lamination of layer 3.

Wall of subtending hyphae, hyaline to golden yellow, 2.8 - 5.8 µm thick at pore level, thinning to 1.0 - 1.4 µm thick 24 - 32 µm distant from the spore.

Mycorrhizae (Fig 1 F,G) arbuscular mycorrhizae with intra- and extraradical spore differentiation, vesicles mainly ovoid to ellipsoid, 12 - 21 X 24 - 42 (64) µm, and arbuscules arising from a central trunk that ramifies 3 to 4 times before branching intensively producing cauliflower shaped structures.

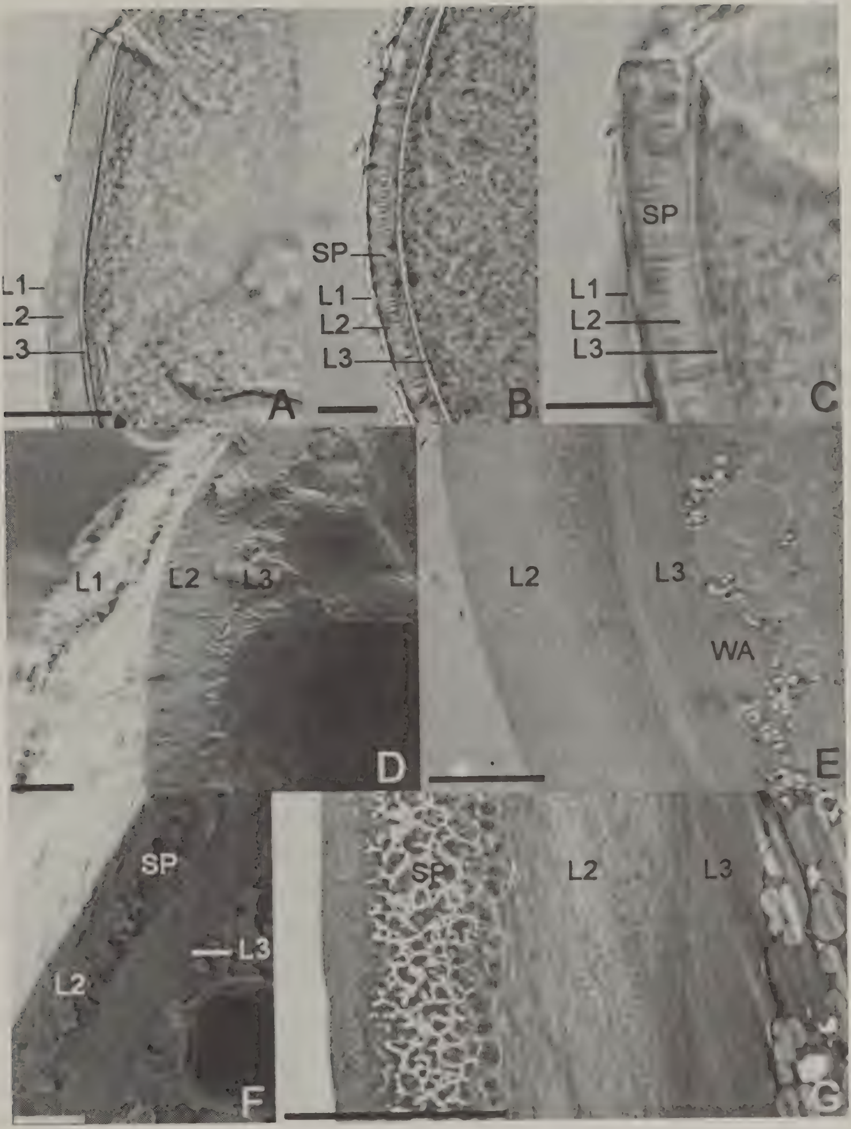
Mycorrhizal association: In the field, isolated from a gravelly mineral soil, from the rhizosphere of *Agrostis stolonifera.* In the greenhouse, pot cultured with *Allium porrum* L.

Distribution: *Glomus kerguelense* is only known from a single site at Port-aux-Français, Scientific Base, Kerguelen Islands, 49 21'S 70 13'E, gravelly mineral soil from a cool oceanic climate with low temperature fluctuating from 2°C in winter to 8 °C in summer.

Etymology: referring to the harvesting locality, Kerguelen Islands, named in honor of the French navigator, Yves-Joseph de Kerguelen de Trémarec, who discovered the Islands in 1772.

Collection examined: FRANCE . Kerguelen Islands Overseas Territory: Port-aux-Français, Feb.1 1998, J-C. Gloaguen. HOLOTYPE DAOM 229603 comprising juvenile and matures spores mounted in PVLG.

Fig 2 A-G Spore wall of *Glomus kerguelense* A. Juvenile spore showing three distinct wall layers (L1, L2, L3); B. Mature spore showing a spongious zone (SP) in the middle laminated wall layer; C. Folded appearance of middle laminated wall layer; D. Juvenile spore wall under SEM; E. Juvenile spore under TEM showing the warty inside ornamentations (WA) of the inner wall (L3); F. Mature spore wall under SEM; G. Mature spore wall under TEM showing lacunar appearance of the spongy layer (SP). (Scale bars A,B,C,= 8 µm; D,E,F,G = 2.5 µm)


L1
L2
L3
A
SP
L1
L2
L3
B
SP
L1
L2
L3
C
L1
L2
L3
D
L2
L3
WA
E
SP
L3
L2
F
SP
L2
L3
G

DISCUSSION

The fine granular appearance of *G. kerguelense* spores, detectable in both juvenile and mature spores, together with the three distinct layers of the spore wall, readily distinguishes the species from most known *Glomus* taxa. The spongy zone differentiated inside the middle laminated wall of mature spores further differentiates the species. The spore ornamentations which occurred at the inner surface of the inside wall layer of *G. kerguelense*, appear to be, with *G. verruculosum* Blaskowski (Blaskowski & Tadych, 1997) unique in *Glomus*.

With other species that differentiated interior ornamented walls such as *G. fistulosum* Skou & Jakobsen (1989), *G. fragilistratum* Skou & Jakobsen (1989), *G. halonatum* Rose & Trappe (1980), and *G. reticulatum* Bhattacharjee & Mukerji (1980), ornamentations always occur at the outer surface of the wall layer, not on the inner surface. In only a few cases, ornamentations can be observed at the inside surface of the wall layer, such as with *G. multiforum* Tadych & Blaszkowski (Blaskowski & Tadych, 1997), and *G. monosporum* Gerdemann & Trappe (1974), but those ornamentations resulted from the print left by the adjacent inner wall. Of the *Glomus* species characterized by a tri-layered wall, such as *G. claroideum* Schenck & Smith (1982), *G. clarum* Nicolson & Schenck (1979), *G. geosporum* (Nicol. & Gerd.) Walker (Walker, 1982) , and *G. lamellosum* Dalpé, Koske & Tews (1992), none has an ornamented inside wall.

When observed under a compound microscope, spores of *G. kerguelense* resemble those of *G. verruculosum* by their size, their inside wall ornamentation, their flared to funnel-shaped hyphal attachment, their septate subtending hyphae, and the absence of spore wall reaction to Melzer's reagent. However, *G. kerguelense* spores differ considerably from *G. verruculosum* in having much paler spore pigmentation, three distinct spore wall layers, a mucilaginous evanescent outer wall compared to the semi-flexible, rigid one of *G. verruculosum*, and the thinner and non-ornamented laminated wall.

The presence of a spongy zone inside the middle laminated wall on *G. kerguelense* spores is a new feature among Glomales. In the present description, it has not been considered as a distinct wall layer because of its sequential differentiation during spore maturation stages and its irregular distribution along the spore wall. In some aspects, it may be associated with a kind of flaw in the spore wall and as such its formation is potentially related to environmental conditions. When examined under a compound microscope, the zone appeared as a series of multiple folds, giving the wall layer a crumpled aspect (Figs 2 B,C). Not detectable in juvenile spores when observed under SEM (Fig. 2D), it appears in mature spores as holes of different sizes separated each other by a fine membrane, similar to a sponge (Fig. 2E). Under TEM, the spongy texture is detectable at the juvenile spore stage (Fig. 2F). It adopts its distinctive reticulated morphology with mature spores (Fig. 2G). Located in juvenile spores within the younger portion of the laminated wall (Fig. 2F), the spongy zone gradually moved toward the outside of the layer with the synthesis of new laminate in this wall layer. Attempts to propagate an isolate on root-organ culture have, up to now, remained unsuccessful but once realized the *in vitro* culture should provide information on the value of this new wall feature for the characterization of the species.

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STELLOMYCES KENDRICKII, A NEW HYPHOMYCETE FROM INDIA

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ABSTRACT

A new species of hyphomycete, *Stellomyces kendrickii*, is described. It produces single, cuneiform or triangular to kite-shaped, unicellular, smooth, colourless, blastic conidia at the tip of each of several very long denticles which radiate from small apical (subsequently intercalary) vesicles on a sympodially extending conidiophore. It was isolated from decaying twigs of *Hopea ponga* (Dennst.) Mabb. (F. Dipterocarpaceae) in the forests of Western Ghats in southern India.

Key words: Biodiversity, tropical fungi, taxonomy.

INTRODUCTION

During studies on the taxonomy and diversity of microfungi, an apparently undescribed hyphomycete was isolated from fallen and decaying twigs of *Hopea ponga* (Dennst.) Mabb. (F. Dipterocarpaceae) from forests of Western Ghats in Goa State, India. The fungus is described as a new species of the genus *Stellomyces* Morgan-Jones, Sinclair & Eicker.

Decaying twigs of *Hopea ponga* gathered from the forests were thoroughly washed in deionized tap water and incubated in a sterile moist chamber in the laboratory. Conidiophores with haloes of conidia appeared on the surface of the twigs after two weeks.

TAXONOMIC PART

Stellomyces kendrickii Keshavaprasad et Bhat anam.-sp. nov. **(Fig.1)**
[Etym: Specific epithet: Named in honour of Dr. Bryce Kendrick, a distinguished mycologist from Canada]

Ad fungos conidiales pertinens. *Coloniae* effusae, subhyalinae vel olivaceae, velutinae. *Mycelium* partim immersum, partim superficiale, ex hyphis septatis, ramosis, incoloris vel pallide olivaceis, 2-2.5 µm lat., compositum. *Conidiophora* erecta, recta vel flexuosa, non-ramosa, solitaria, angustata versus apicem, septata, tenuitunicata, laevia, hyalina, 20-100 x 1.5-2.5 µm, extendentia sympodialiter et ferentia fasciculos conidiorum apicales et intercalares. *Cellulae conidiogenae* polyblasticae, integratae,

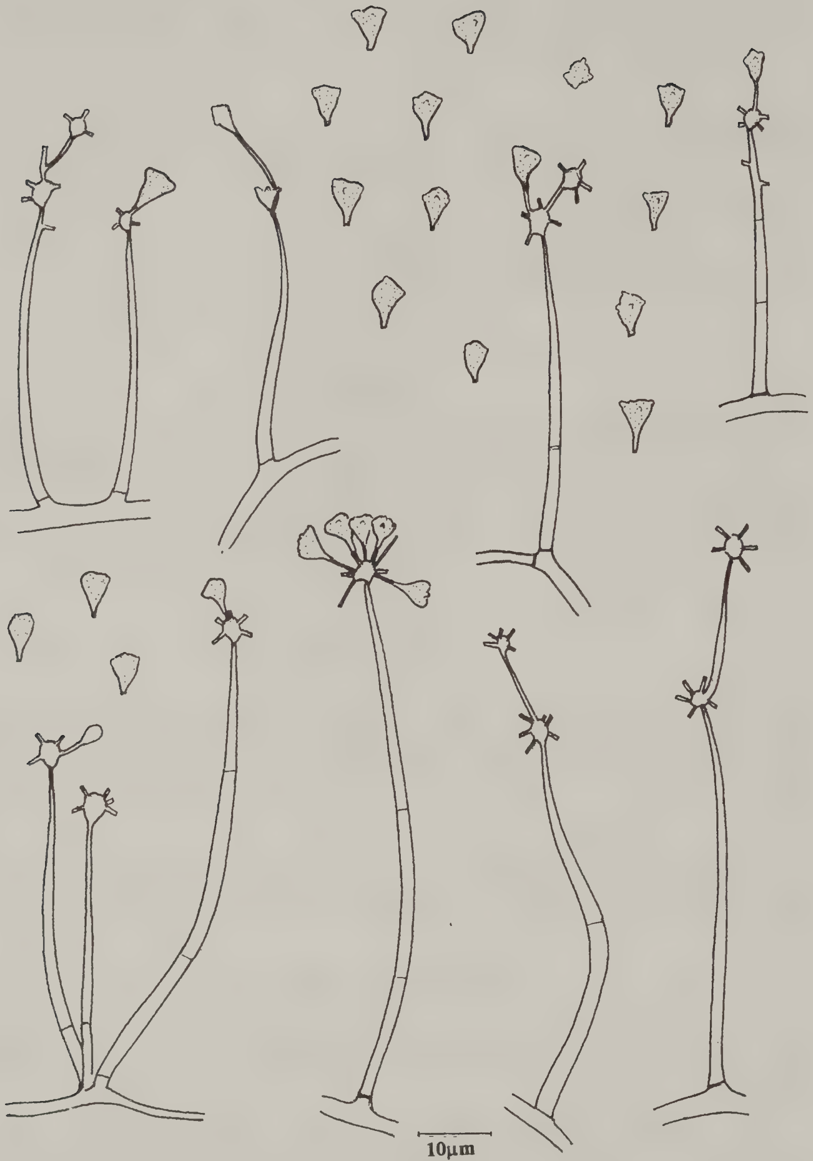

Fig. 1. *Stellomyces kendrickii* sp.nov.

terminalis vel intercalaris, hyalina vel olivacea, laevia, apicem instar stellae versus denticulis numerosis, 2-4 µm long. praeditae. *Conidia* solitaria, obovoidea vel obconica, cuneiforma vel triangularia, non-septata, crassitunicata, levia, hyalina vel olivacea, 4-5 x 3-4 µm, evolutum verticillatim.

HOLOTYPUS, In virga putrescentibus *Hopea ponga,* Sri Bhagwan Mahaveer Wildlife Sanctuary, Mollem, Goa , India, 17.10.2001, leg. Keshavaprasad, Herb. No. IMI 388263.

Terrestrial litter hyphomycete. *Colonies* spreading, almost colourless to olivaceous green, velvety. *Mycelium* partly immersed, partly superficial, composed of septate, branched, colourless hyphae 2-2.5 µm wide. *Conidiophores* arising from prostrate vegetative hyphae, single, erect, straight or flexuous, tapering above, septate, thin-walled, smooth, colourless to olivaceous, 20-100 x 1.5-2.5 µm, forming first crop of conidia on denticles arising from a swollen apical vesicle, with subsequent groups of conidia developing on new vesicles at higher levels, originally apical conidiogenous vesicles later becoming intercalary. *Conidiogenous cells* polyblastic, integrated, terminal or intercalary, colourless to pale olivaceous green, thin-walled, 3-5 µm diam., with denticulate fertile projections 2-4 µm long radiating from the swollen distal vesicle. *Conidia* solitary, obovoid to obconical, cuneiform or triangular, or kite-shaped, non-septate (amerosporous), thick-walled, smooth, colourless to olive green, with small projections at the corners, 4-5 x 3-4 µm, tapering below to form a narrow stalk, developing in whorls or halos.

The monotypic genus *Stellomyces* Morgan-Jones *et al.* (1987), with *S. suidafrikanus* Morgan-Jones, Sinclair & Eicker as type, was established for a hyphomycetous fungus producing gently curved, navicular, non-septate, colourless conidia on radially arranged long denticles arising from apically swollen conidiogenous cells and sympodially proliferating mononematous conidiophores. In its general morphology, *S. kendrickii* is clearly congeneric with *S. suidafrikanus*, but differs from the type species in the shape and size of its conidia, which are cuneiform and 4-5 x 3-4 µm, (the conidia in *S. suidafrikanus* are larger, 8-10 x 3-5 µm), and in its globose fertile vesicles and shorter denticles: the conidiiferous denticles in *S. kendrickii* are 2-4 µm long, while those of *S. suidafrikanus* are 4-7 µm long.

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KUMBHAMAYA JALAPRIYA, A NEW ENDOPHYTIC HYPHOMYCETE FROM INDIA

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ABSTRACT

A new species of endophytic dematiaceous hyphomycete, *Kumbhamaya jalapriya,* producing falcate to vermiform, non-septate, colourless phialoconidia, was isolated from submerged live roots of *Hoppea ponga* (Denst) Mabb. (F. Dipterocarpaceae) from a perennial stream in the forests of Western Ghats in southern India.

Key words: Biodiversity, tropical fungi, taxonomy, limnology.

INTRODUCTION

Riparian trees often extend part of their root system into streams and rivers. Since aquatic hyphomycetes are the major colonizers of plant detritus in running waters, it seemed likely that they would infect healthy or decaying roots underwater. This was confirmed by Fisher *et al.* (1991) who examined the bark and xylem of aquatic roots of *Alnus glutinosa* (L.) Gaertner. To-date, 20 species have been reported as root endophytes from three angiosperm plants, viz. *Acer spicatum* Lam., *Alnus glutinosa* and *Betula papyrifera* Marsh. (Marvanova & Fisher, 1991; Marvanova *et al.,* 1992; Sridhar & Barlocher, 1992a, 1992b.) and one gymnosperm, *Picea glauca* (Moench) Voss (Sridhar & Baerlocher, 1992a) generally found occurring along streams and rivers in temperate regions. Although the role of root-associated freshwater hyphomycetes in plant nutrition, root absorption efficiency, senescence and susceptibility to disease remains to be investigated, the occurrence of these fungi as root endophytes has undoubtedly added new dimensions to the known roles of aquatic hyphomycetes in stream ecosystems (Iqbal *et al.* 1995)

Live roots of *Hopea ponga* (Denst) Mabb. (F. Dipterocarpaceae) submerged in a perennial stream at Mollem Wildlife Sanctuary, Goa, India, were collected in sterile polythene bags and transported to laboratory in an ice-pack container. Root segments were surface-sterilized by immersing in 96% ethanol (1 m), sodium hypochlorite (3 m) and 96% ethanol (0.5 m) and thoroughly rinsed in sterile distilled water. The root segments were cut into smaller pieces of about 0.5 cm and plated on 2% Malt extract agar plates with added antibiotics (Penicillin G ml-1 0.4mg, Streptomycin sulfate, 0.4mg). The plates were incubated at 20°C. for 6-10 days and the hyphae emerging from cut ends of the roots were transferred to fresh MEA slants. Of the several morphotypes isolated as root endophytes, a sporulating dematiaceous hyphomycete was found to be new and is described below.

TAXONOMIC DESCRIPTION

Kumbhamaya jalapriya Sreekala et Bhat **sp. nov.** (Fig. 1)
(Etym. Specific epithet in Sanskrit, jala (= water) priya (= loving).

Coloniae in cultura MEA planae, orbiculatae, ordinatae, cinereae, olivacio- ad fusco-griseae, 4 cm diam. in 10 d; marginis serratis, inversum atropunctatis. *Mycelium* perparce superficiale, partim immersum, ex hyphis primariis et secundariis compositum. Hyphae primariae 3-12 µm lat., crassitunicatae, brunneolae; hyphae secundariae 2-4 µm lat., tenuitunicatae, hyalinae. *Conidiophora* enatus hyphis primariis, mononematosa, erecta, flexuosa, septata, crassitunicata, ramosa, pallide brunnea vel brunnea, 15-40 µm longa, 3-5 µm lat. *Cellulae conidiogenae* monophialidicae, ampullaceae, pallide brunneae, 10-30 µm long. et 3-4 µm lat. ad basim, angustatae longicollus regionis 1-2 µm lat. *Conidia* solitaria, falcata, vermiformia, crispata, hyalina, non-septata, levia, 15-30 µm long., 2-3.5 µm lat.

HOLOTYPUS, In culturis derivata radicis submerses, *Hopea ponga* (Denst) Mabb, IMI 386171, Mollem Wildlife Sanctuary, Goa, India, 20.9.2000, leg. Sreekala. K. Nair.

Colonies on malt extract agar flat, circular, with serrated margin, olivaceous grey to dark green, 4-cm diam. in 10 d; reverse of colony black. *Mycelium* sparse, superficial, composed of primary and secondary hyphae; primary hyphae thick-walled, septate, slightly constricted at the septa, medium brown, 3-12 µm wide; secondary hyphae thin-walled, septate, colourless, 2-4 µm wide, developing from primary hyphae. *Conidiophores* mononematous, erect, flexuous, septate, thick-walled, branched, smooth, pale to medium brown, 15-40 x 3-5 µm, developing from primary hyphae. *Conidiogenous cells* monophialidic, flask-shaped, smooth, with a narrow neck, pale brown, 10-30 µm long, 3-4 µm wide at the base, 1-2 µm wide above, without collarette. *Conidia* solitary, falcate to vermiform, strongly curved to curled, non-septate, smooth, colourless,15-30 µm long, 2-3.5 µm wide in the middle, tapering toward each end.

The genus *Kumbhamaya* M.Jacob & Bhat (2000), typified by *K. indica* Jacob & Bhat, was described for an endophytic dematiaceous hyphomycetous fungus producing fusiform, curved, septate, colourless conidia on kettle- or pitcher-shaped conidiogenous cells (phialides) with conspicuous, flared collarettes. The second species, *K. goanensis* Maria & Bhat (2001) differs from the type by its smaller conidiogenous cells and conidia. The conidiogenous cells and conidia in *K. indica* are12-50 x 2.5-8.5 µm and 25-40 x 3.5-5.5 µm whereas these in *K. goanensis* are 8-11.5 x 2.5-6.5 µm and 7-25 x 1.5-2.5 µm. *K. jalapriya,* an aquatic root endophyte, differs from other two species by its falcate to vermiform, often recurved, non-septate conidia, 15-30 x 2-3.5 µm, produced on relatively smaller conidiogenous cells (10-30 x 3-4 µm) which lack flared collarettes.

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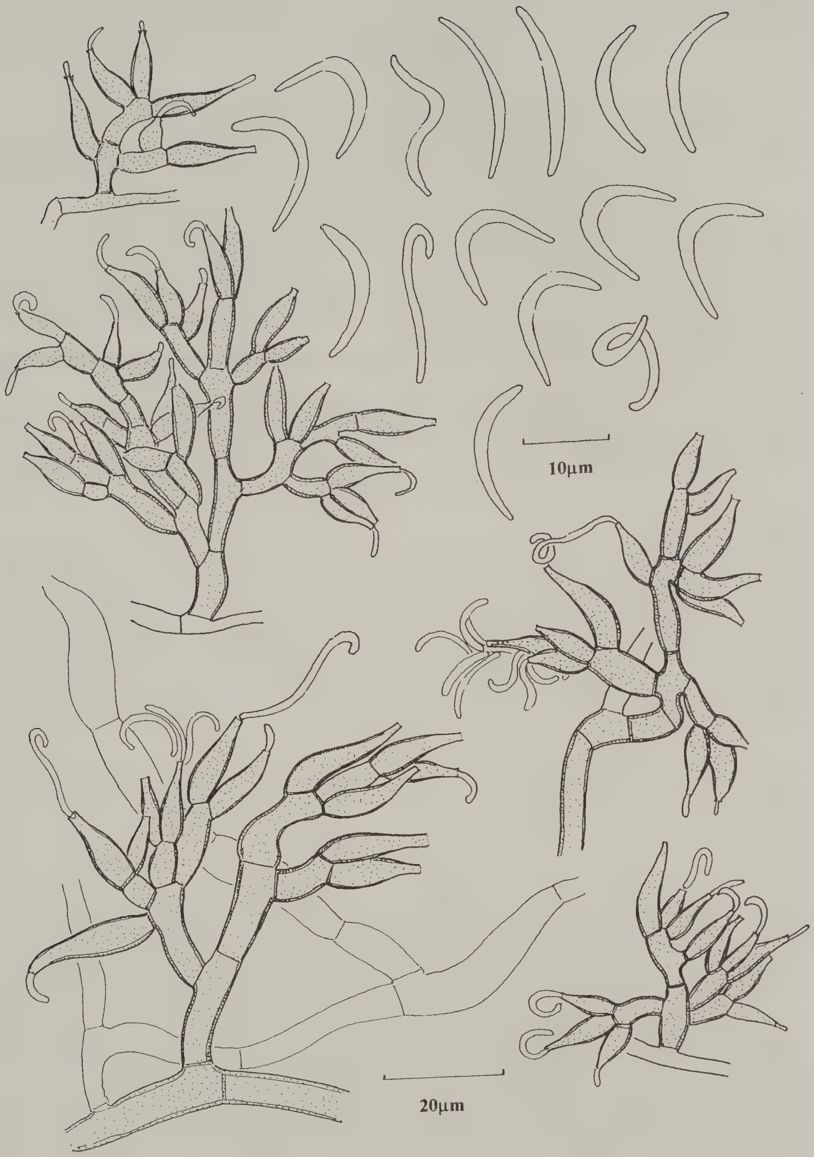

Fig. 1. *Kumbhamaya jalapriya* sp. nov.

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NOTES ON HYPHOMYCETES. LXXXIX. CONCERNING THE GENUS SPHAEROSPORIUM

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ABSTRACT

The taxonomic and nomenclatural history of the genus *Sphaerosporium* and its type species, *S. lignatile*, is reviewed. This anamorph, together with a second species, *S. equinum*, is redescribed and illustrated. An emended generic description is provided. They are briefly compared with certain other anamorphs which bear similarly-pigmented, thick-walled, chlamydospore-like conidia.

KEYWORDS: *Allescheriella, Botryotrichum, Haplotrichum*, generic concepts.

INTRODUCTION

During the course of revisionary studies in the *Acladium-Alysidium-Haplotrichum* complex, including some mitosporic states of *Botryobasidium* Donk [Botryobasidiaceae, Stereales, Basidiomycetes] (Partridge *et al.*, 2001a; 2001b; 2002), several anamorphs which could, conceivably, be confused with, or mistaken for, one or other of the taxa now classified in *Haplotrichum* Link:Fr., have come to our attention. Among these is *Sphaerosporium lignatile* Schwein., the type species of *Sphaerosporium* Schwein., an entity which, like members of the genus *Haplotrichum*, occurs on dead wood and forms ochraceous-colored colonies. The growth pattern of the aerial mycelium of *S. lignatile* is, however, unlike that typical of *Haplotrichum* species in being restricted, pulvinate, orbicular and sporodochium-like, rather than widely effuse, hypochnoid. This taxon has the added characteristic in common with some *Haplotrichum* species of producing chains of yellowish-colored conidia although these mature basipetally rather than acropetally, as is the case in the latter. Furthermore, *S. lignatile* conidia bear some similarity to those of certain taxa currently classified in *Haplotrichum*, such as *H. croceum* (Mont.) Partridge & Morgan-Jones [=*Allescheriella crocea* (Mont.) S. Hughes] and *H. pulveraceum* (Ellis) Partridge & Morgan-Jones, in being markedly thick-walled and chlamydospore-like.

The generic name *Sphaerosporium* has had a rather checkered nomenclatural history. Although Saccardo (1886) pointed out a similarity between *Sphaerosporium* and *Coccospora* Wallr. it was maintained by him as a separate entity but von Höhnel (1911) considered the two to be synonymous. The latter author adopted *Coccospora* [1833] as the valid name, despite the fact that *Sphaerosporium* [1832] predated it by a year, and this was subsequently followed by Clements and Shear (1931). Shear (1939), however, noted the error and, following a study of part of the original collection of *S. lignatile* and a consideration of Wallroth's description of *Coccospora aurantiaca* Wallr., the type species of *Coccospora*, determined the two genera to be quite different, thus effectively reestablishing the former status of *Sphaerosporium*. In a comprehensive taxonomic study of the genus *Coccospora,* Damon and Downing (1954) reached the same conclusion with regard to the distinctiveness question. Examination of the type material of *C. aurantiaca* by these authors revealed the anamorph to be sclerotial in nature and, moreover, to be different not only from *S. lignatile* but from other species added to the genus since its inception. Some of these latter taxa were shown to represent synonyms, based on such entities as *Allescheriella crocea* [now, as noted above, *Haplotrichum croceum*], *Botryotrichum piluliferum* Sacc. & Marchal and *Mycogone rosea* Link, whilst others could not be satisfactorily characterized, nor their identity accurately determined. In the case of *Coccospora casei* P. Karst., described from cheese in Finland, Damon and Downing (loc.cit.), following examination of its type specimen, expressed the view that it appeared more closely related to *S. lignatile* than to *C. aurantiaca,* being similar to the former in producing thick-walled conidia in chains but differing in conidial size. It may well be a good species of *Sphaerosporium* although the substrate difference might certainly lead one to suspect that it is not.

At least two other binomials appear to have been applied to *S. lignatile,* namely *Oidium megalosporum* Berk., as pointed out by Linder (1942) and confirmed by Damon and Downing (loc.cit.) and *Protomyces xylogenus* Sacc., according to Shear (1939). A study of type and other material of this taxon by the present authors has afforded opportunity to provide a treatment of it. An amplified description of the genus on which it is based is included herein, as is consideration of a second species, *Sphaerosporium equinum* (Desm.) J.L. Crane & Schokn. [≡ *Torula equina* Desm.]. These two taxa are redescribed and illustrated. The descriptive emendation of the genus characteristics is not, in accordance with the directive contained in Article 47 of the ICBN, formalized by an author citation since the type species is not excluded. The status of a third species, *Sphaerosporium argentinense* Speg., described as forming broadly effuse, flesh-colored sporodochia on unidentified, decaying branches in Argentina and possessing thick-walled, subglobose-angulated, hyaline conidia (Spegazzini, 1910), remains in abeyance until such time as its type is examined in light of the modern, more-detailed characterization of the genus peculiarities. Likewise in the case of *Coccospora casei* described by Karsten [in Karsten, Roumeguere and Hariot (1890)] and referred to above. Given the fact that the conidia of *S. argentinense* are said to be colorless and there is no mention in its type description of their being borne in chains it seems very unlikely that it is congeneric with *S. lignatile*.

TAXONOMIC PART

Sphaerosporium Schwein., *Trans. Am. Phil. Soc.* n.s. 4: 303, 1832.

Colonies discrete, restricted, orbicular, pulvinate, sporodochium-like, gregarious, occasionally becoming confluent and assuming a somewhat effuse appearance, buff to ochraceous-orange in color. Mycelium partly superficial, partly immersed, composed of branched, hyaline to subhyaline, septate, smooth, cylindrical hyphae; where superficial tightly interweaving with the hyphae often becoming slightly inflated along their length but constricted at the septa, giving a somewhat torulose appearance. Conidiophores micronematous, mononematous, ascending in tight clusters, more or less straight or, more often, flexuous, mostly branched, torulose, smooth, hyaline to subhyaline, of varying length, usually arising from a subtending, localized mass of repent hyphae. Conidiogenous cells monoblastic, integrated. Conidia formed in simple or branched basipetal chains, dry, unicellular, smooth, ellipsoidal to subglobose or globose, thick-walled, subhyaline to pale yellow or yellowish-orange, distinctly truncate at locus or loci of original attachment.

Type species: *Sphaerosporium lignatile* Schwein.

Sphaerosporium lignatile Schwein., *Trans. Am. Philos. Soc.* n.s. 4: 303, 1832 (Figure 1).

= *Oidium megalosporum* Berk. & M.A. Curtis, *J. Linn. Soc. London, Bot.* 10: 363, 1869.

= *Protomyces xylogenus* Sacc., *Michelia* 1, 14: 1877 [*fide* Shear (1939)].

Colonies at first discrete, restricted, orbicular, pulvinate, dense, distinctly sporodochium-like or somewhat looser organized, gregarious, occasionally becoming confluent and appearing effuse with thinner, flat, connecting growth at the periphery, pale buff to ochraceous-buff, more intensely colored with age; where remaining discrete up to 2 mm in diameter. Mycelium partly superficial, partly immersed, composed of branched, hyaline to subhyaline, septate, smooth, cylindrical, 3 to 5 µm wide hyphae; where superficial, tighly interweaving to form a cushion-like mass with the hyphae often becoming variously inflated along their length, up to 14 µm wide when distinctly swollen, but constricted at the septa to give a somewhat torulose appearance. Conidiophores micronematous, mononematous, ascending in tight, densely-caespitose clusters, flexuous, mostly branched, torulose, smooth, hyaline to subhyaline, up to 90 µm long, arising from a subtending, localized mass of hyphae, with terminal and subterminal cells becoming progressively converted basipetally into conidia. Conidiogenous cells monoblastic, integrated. Conidia formed in simple or branched basipetal chains which disarticulate schizolytically, dry, unicellular, smooth, ellipsoidal to globose, markedly thick-walled, pale yellow when mature and often densely granular, frequently with one or several prominent guttules, distinctly truncate at the locus or loci of attachment, 38 to 50 µm in diameter where globose, 39-64 X 34-50 µm in size where ellipsoidal, with the refractive, glass-like wall becoming up to 6 µm thick at maturity.

On dead bark and decorticated wood; North America.

Specimens examined: on dead wood, Bethlehem, Pennsylvania, USA, Lewis David von Schweinitz, undated, Syn. Fung. #3036, PH, holotype; on dead wood, Cincinnati, Ohio, USA, A.P. and L.V. Morgan, 188-, BPI; on dead wood, Groveton, Virginia, USA, C.L. Shear, 6 October 1928, BPI; Oviedo, Florida, USA, C.L. Shear, 14 February 1938, BPI; on rotten log, west of Maple, York County, Ontario, Canada, Roy F. Cain, 22 October 1938, BPI; Beltsville, Maryland, USA, F. Petrak, September 1950, BPI; on

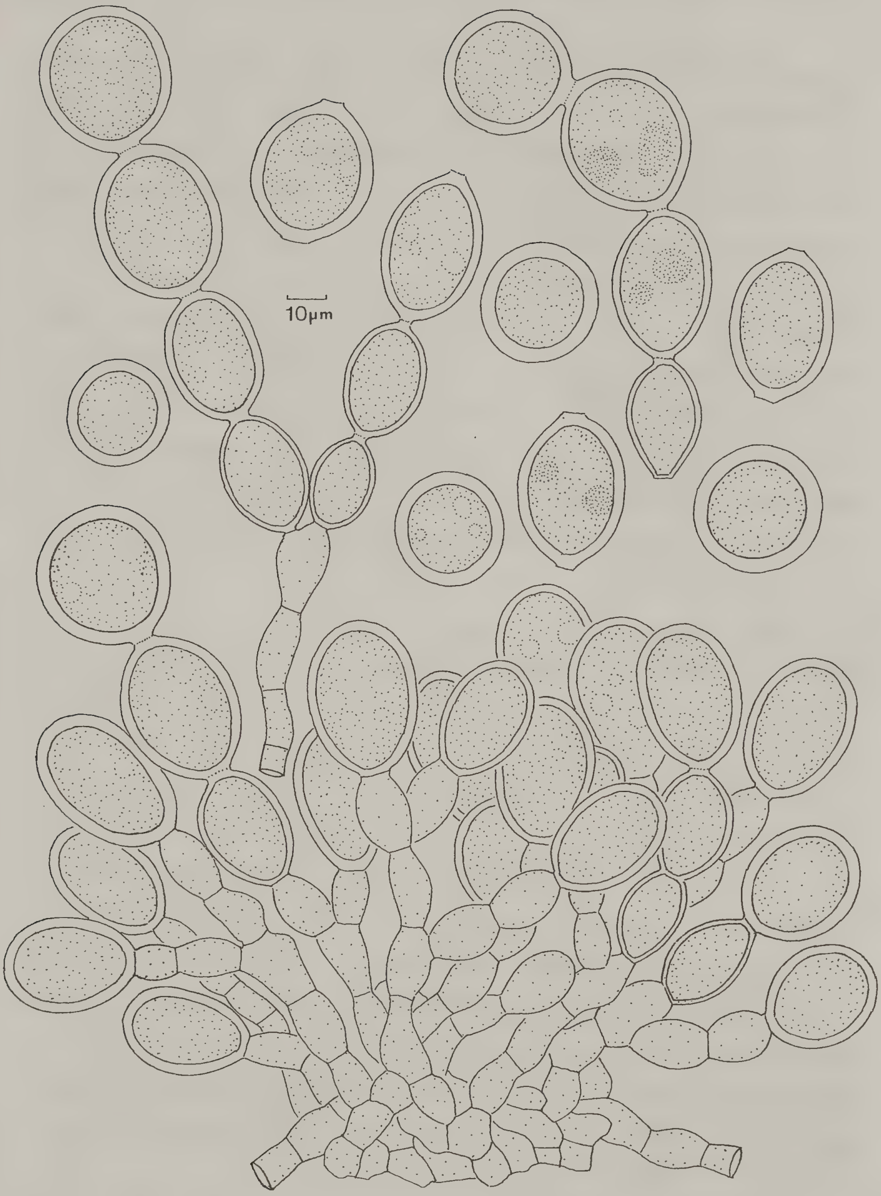

FIGURE 1. *Sphaerosporium lignatile*. Conidiophores and conidia.

wood and bark of dead *Carya* sp., Moorefield Twp., Buck Creek Lake State Park, Clark County, Ohio, USA, Michael A. Vincent, 13 October 1989, BPI.

In terms of colony characteristics, including coloration, *Sphaerosporium lignatile* can appear deceptively similar to some species of *Haplotrichum,* both to the naked eye and when viewed under the stereomicroscope. This is particularly the case where well-developed colonies of *S. lignatile* become confluent and appear more effuse than is typical. There exists some variation among herbarium-housed material with regard to the exact nature of the colonies, perhaps reflecting differences in environmental, climatic and substrate growth conditions. In some specimens, external mycelial growth is restricted in the form of scattered, discrete, tightly-packed, interweaving clusters of hyphae whereas in others growth is looser, thinner and more effuse. There is some difference also in coloration. Where superficial hyphal growth is confined and sporodochium-like colonies generally have more intense coloration ranging from ochraceous-buff to a cinnamon hue. In this connection it should be noted that there exists some indication in the literature that fresh collections tend to be paler, more yellowish in appearance and are somewhat gelatinous [see Damon and Downing (loc.cit.)].

With regard to the peculiarities of the conidia, particularly their pigmentation and wall thickness, as alluded to above, *S. lignatile* bears some resemblance to such species of *Haplotrichum* as *H. croceum* and *H. pulveraceum.* It is, however, readily distinguished from these taxa. In the former conidia are formed solitarily whereas in the latter conidia are formed in acropetal succession. The conidia of *S. lignatile* are also strikingly similar in appearance to those of *Botryotrichum piluliferum*, the anamorph of *Chaetomium piluliferum* Daniels, by being more or less globose and having very thick, refractive walls, which accounts for the fact that the latter has, in the past, been confused with *Coccospora*, of which *Sphaerosporium,* as already noted, was long thought to be a synonym. The binomial *Coccospora agricola* Goddard is a facultative synonym of *B. piluliferum* [see White and Downing (1951), Downing (1953)]. The presence of somewhat similar-appearing conidia in these anamorphs is presumably reflective of morphological convergence of phylogenetically disparate elements. Whether or not *Sphaerosporium* has, like *Haplotrichum,* basidiomycetous affinity remains a matter for speculation.

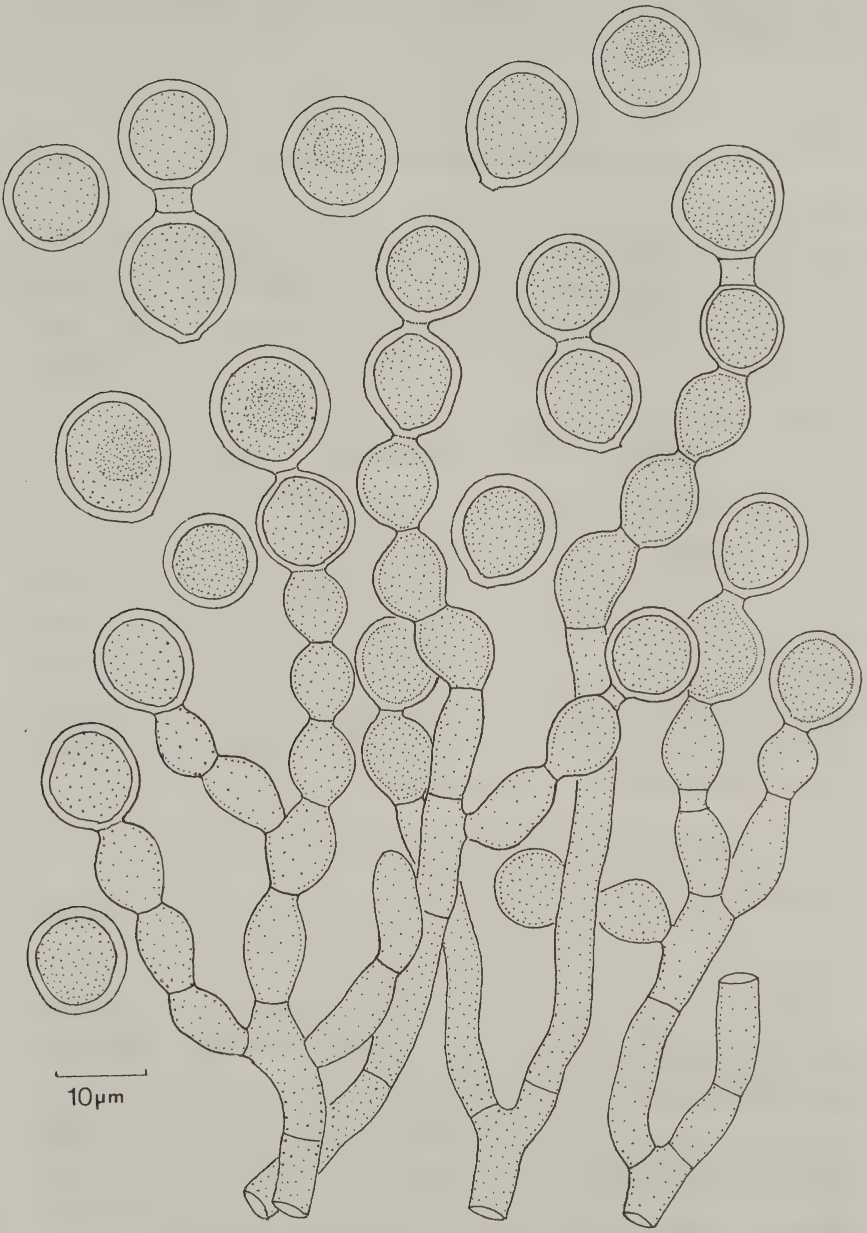

FIGURE 2. *Sphaerosporium equinum*. Conidiophores and conidia.

Sphaerosporium equinum (Desm.) J.L. Crane & Schokn., *Mycologia* 78: 86, 1986 (Figure 2).

= *Torula equina* Desm., *Ann. Sci. Nat. Bot. Sér.* 4, 4: 126, 1855.

= *Oospora equina* (Desm.) Sacc. & Voglino, *Syll. Fung.* 4: 22, 1886.

Colonies discrete, restricted, orbicular, pulvinate, gregarious, occasionally becoming confluent, pale ochraceous buff to ochraceous-orange in color. Mycelium partly superficial, partly immersed, composed of branched, hyaline to subhyaline, septate, smooth, cylindrical, 3-4.5 µm wide hyphae; where superficial forming a lax, localized network with individual elements becoming somewhat torulose toward the distal, fertile reaches. Conidiophores micronematous, mononematous, ascending and interweaving, more or less straight or flexuous, simple or loosely branched, cylindrical to torulose, smooth, hyaline to subhyaline, varying in length up to 100 µm, with distal cells becoming progressively converted basipetally into relatively long chains of conidia. Conidiogenous cells monoblastic, integrated. Conidia formed in simple or branched basipetal chains which disarticulate schizolytically, dry, unicellular, smooth, at first ellipsoidal, becoming subglobose to globose at maturity and detachment, markedly thick-walled, subhyaline to pale yellowish-orange, granular, often with a single, large guttule, truncate at locus or loci of attachment, 7.5 to 12 µm in diameter where globose, 7.5-12.5 X 6-11 µm in size where ellipsoidal to subglobose, with the wall up to 1.5 µm thick at maturity.

On old and humid horse hoofs; Europe.

Specimen examined: J.B.H.J.Desmazières, H.G. 1510 (PC), ex neotype ILLS.

In colony appearance and coloration *S. equinum* is quite similar to *S. lignatile,* differing only slightly from the typical sporodochium-like aspect of the latter in being somewhat looser organized. As noted by Crane and Schoknecht (1986) the two species differ considerably in conidium size, those of *S. equinum* being much smaller. The thallic conidiogenesis where pre-existing, determinate, swollen, hyphal elements are basipetally converted into conidia, followed by arthric disarticulation, is essentially identical however. An additional small difference between the two taxa lies in the fact that in *S. equinum* not all delimited cells along the length of the fertile, distal portion of the conidiophores invariably become swollen and retrogressively converted into conidia. In some chains an occasional intercalary cell may, at a given time, remain unmodified while adjacent cells, on either side, assume the size and form of conidia. Apart from the notable substrate difference there is, at present, little reason to question the presumed relatedness of these taxa.

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THREE NEW SPECIES OF THE GENUS MELIOLA FROM CHINA

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ABSTRACT

Meliola fagacearum parasitic on *Lithocarpus* sp., *Meliola hui* on *Buchanania latifolia* and *Meliola simaoensis* on *Viburnum cylindricum*, are described and illustrated as new species.

KEY WORDS: *Meliola fagacearum, Meliola hui, Meliola simaoensis,* China

Meliola Fr. is the largest genus of the Meliolaceae (Meliolales). This genus differs from other genera of Meliolaceae in having hyphal setae on the mycelium and lacks vermiform appendages on perithecial surface (Hansford, 1961; Hosagoudar, 1992). Over 1625 species of *Meliola* have been described and 239 species have been reported in China (Hawksworth *et al.*, 1995; Hosagoudar *et al.*, 1997; Hu *et al.* 1996,1999; B. Song *et al.*, 1997).

Meliola fagacearum B. Song & R. D. Goos sp. nov. (Fig. 1)

Coloniae epiphyllae, atrae, velutinae, dispersae, ad 10 mm diam., raro confluentes. Hyphae atro-brunneae, rectae vel undulatae, opposite acuteque ramosae, dense reticulatae, cellulis 15-25×5-7 μm. Appressoria opposita vel ad 1% alternata, antrorsa, recta vel subrecta, 10-20 μm longa; cellulae basilares cylindraceae, 3-6.4 μm longae; cellulae apicales conoideae, apice subacutae, integrae, 7.4-14.4×6-7 μm. Phialides et illis appressoria immixta, oppositae vel alternatae, ampullaceae, 17-23×5.5-7μm. Setae myceliales dispersae, atrae, simplices, rectae vel leniter curvulae, apice acutae vel subacutae, ad 530μm longae vel basis 6.4-7.2 μm latae. Perithecia dispersa, nigra, globosa, verrucosa, ad 270μm diam.; ascosporae atrobrunneae, oblongae vel subellipsoidea, obtusae, 4-septatae, constrictae, 27-34 ×12-17 μm.

Colonies epiphyllous, black, velvety, scattered, up to 10 mm in diameter, rarely confluent. Hyphae brown, straight to undulate, branching opposite at acute angles, closely

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reticulate; cells 15-25×5-7 μm. Appressoria in opposite to 1% alternate arrangement, antrorse, straight to nearly straight, 10-20 μm long; stalk cells cylindrical, 3-6.4 μm long; head cells conoid, nearly acute at apex, entire, 7.4-14.4×6-7μm. Phialides mixed with appressoria, in opposite to alternate arrangement, ampulliform, 17-23×5.5 -7 μm. Mycelial setae scattered, black, simple, straight to slightly curved, acute to nearly acute at apex, up to 530 μm long, 6.4-7.2 μm broad at base. Perithecia scattered, black, globose, verrucose, up to 270 μm in diameter; ascospores brown, oblong to nearly ellipsoidal, obtuse, 4-septate, constricted at septa, 27-34×12-17 μm.

Holotype: On leaves of *Lithocarpus* sp.(Fagaceae). Wuzhi Shan, Hainan Province, China. May 16, 1988, Hu Yanxing HMIGD 30952.

Etymology: *fagacearum*, in reference to the host, Fagaceae.

This species is close to *Meliola ramulicola* Yam.(Hansford, 1961), but differs from the mycelial setae of the latter are branching and toothed at the apex.

Meliola hui B. Song, R.D. Goos & T. H. Li sp. nov. (Fig. 2)

Meliola buchananiae auct. non Stev. ex Hansf.:Hu, Lu et Jiang, Acta Mycol. Sinica 8(3):183. 1989.

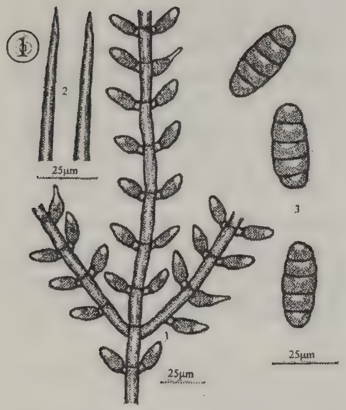
Coloniae amphigenae, nigrescentes, velutinae, densae, dispersae, ad 3 mm diam., raro confluentes. Hyphae atro-brunneae, rectae vel undulatae, opposite et plermque acuteque ramosae, dense reticulatae, cellulis 15-38×7.2-9 μm. Appressoria alternata vel unilateralia, antrorsa, recta vel leniter curvata, 18-28 μm longa; cellula basali cylindracea vel cuneata, 5-10 μm longa; cellula apicali oblonga, integra,12.7-18×9-13 μm. Phialides plerumque separata, opposita vel alternata, ampullacea, 15-25×7-9μm. Setae myceliales dispersae vel interdum juxta perithecium aggregata, atrae, simplices, rectae vel leniter curvulae, apice acutae, ad 820 μm longae vel basis 10-14 μm latae. Perithecia aggregata, nigra, globosa, verrucosa, ad 220μm diam.; ascosporae atro-brunneae, ellipsoideae vel oblongae, obtusae, 4-septatae, constrictae, 53-65×17-29μm.

Colonies amphigenous, black, velvety, dense, scattered, up to 3 mm in diameter, rarely confluent. Hyphae brown, straight to undulate, branching mostly opposite at acute angle, closely reticulate; cells 15-38 × 7.2-9 μm. Appressoria in alternata arrangement, unilateralia, antrorse, straight to slightly curved, 18-28 μm long; stalk cells cylindrical to cuneate, 5-10 μm long; head cells oblong, entire, 12.7-18×9-13 μm. Phialides mostly separate, opposite to alternate, ampulliform, 15-25 × 7-9μm. Mycelial setae scattered, sometimes grouped around perithecium, black, simple, straight to slightly curved, acute at apex, up to 820μm long, 10-14 μm broad at base. Perithecia aggregate, black, globose, verrucose, up to 220 μm in diameter; ascospores brown, ellipsoidal to oblong, obtuse, 4-septate, constricted at septa, 53-65×17-29 μm.

Holotype: On leaves of *Buchanania latifolia* Roxb.(Anacardiaceae). Lingshui, Hainan Province, China. Sept. 9, 1975, Ye Donghai HMIGD 30910 .

Etymology: this species is named in honour of the late Prof. Y. X. Hu of our institute for his outstanding contributions to study on the Meliolales from China.

This species is close to *Meliola buchananiae* Stev. ex Hansf. (Hansford, 1961) but differs from it in having longer appressoria, mycelial setae and larger ascospores. It is also



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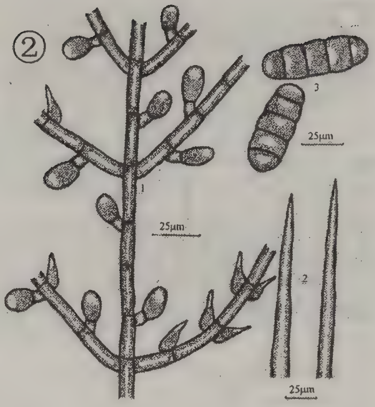

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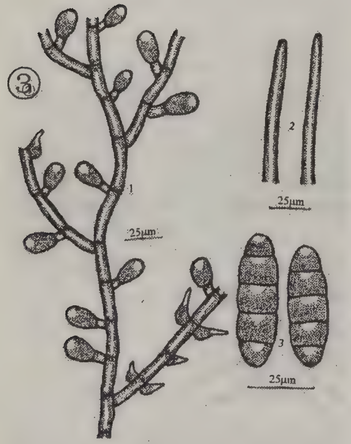

③

Figs. 1-3. 1.Hyphae with appressoria and phialides; 2. . Mycelial setae; 3. Ascospores.

Fig.1 *Meliola fagacearum* B. Song & R. D. Goos

Fig.2 *Meliola hui* B. Song, R.D. Goos & T. H. Li

Fig. 3 *Meliola simaoensis* B. Song & R. D. Goos

close to *Meliola buchananiicola* Hosagoudar (Hosagoudar *et al.*, 1990), but differs in having longer appressoria and smaller ascospores.

Meliola simaoensis B. Song & R. D. Goos sp. nov. (Fig. 3)

Coloniae epiphyllae, nigrescentes, velutinae, densae, dispersae, ad 3 mm diam., raro confluentes. Hyphae atro-brunneae, subrectae vel undulatae, alternatae plermque acuteque ramosae, dense reticulatae, cellulis 18-28×7-8 μm. Appressoria alternata vel unilateralia, antrorsa, plermque curva, 24-42μm longa; cellula basali cuneata vel subcylindracea, rectae vel curvae, 4-18 μm longa; cellula apicali ellipsoidea vel clavata, apice obtusa, integra, 15-24 ×10-18μm. Phialides et illis appressoria immixta, opposita vel alternata, ampullacea vel conoidea, 15-30×7-10μm. Setae myceliales juxta perithecium aggregata, laxe, atrae, simplices, rectae, apice obtusae, ad 360μm longae vel basis 9-11μm latae. Perithecia dispersa vel subaggregata, nigra, globosa, verrucosa, ad 180μm diam.; ascosporae atro-brunneae, oblongae vel cylindraceae, obtusae, 4-septatae, constrictae, 45-56×17-20 μm.

Colonies epiphyllous, black, velvety, dense, scattered, up to 3 mm in diameter, rarely confluent. Hyphae brown, nearly straight to undulate, mostly branching alternate at acute angle, closely reticulate, cells 18-28 × 7-8μm. Appressoria in alternate to unilateral arrangement, antrorse, mostly curve, 24-42μm long; stalk cells cuneate to cylindrical, straight to curved, 4-18 μm long; head cells ellipsoidal to clavate, obtuse at apex, entire, 15-24×10-18μm. Phialides mixed with appressoria, opposite to alternate, ampulliform to conoid, 15-30×7-10 μm. Mycelial setae crowed around perithecia, choose, few, black, simple, straight, obtuse at apex, up to 360 μm long, 9-11 μm broad at base. Perithecia scattered to slightly crowded, black, globose, verrucose, up to 180μm in diameter; ascospores brown, oblong to cylindrical, obtuse, 4-septate, constricted at septa, 45-56× 17-20μm.

Holotype: On leaves of *Viburnum cylindricum* Buch.-Ham. (Caprifoliaceae). Simao, Yunnan Province, China. May 11, 1957, Xu Lianwang et al. HMAS 45739.

Etymology: *simaoensis*, in reference to the locality from which the specimens were collected.

The present species is close to *Meliola yuanjiangensis* Jiang and *Meliola aequatoriensis* Petrak (Hansford, 1961), but differs from the later in possessing smaller appressoria and ascospores.

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We are deeply grateful to Dr. J. L. Crane of Illinois Natural History Survey (U.S.A.) for reviewing the manuscript. We are indebted to Prof. V.B. Hosagoudar of Microbiology Division, Tropical Botanic Garden and Research Institute, Palode (India) for his help in various ways, and to the Herbarium Mycologicum Academiae Sinicae (HMAS) for the loan of specimens, and especially acknowledge Prof. Chen Shaoqing of the South China Institute of Botany, Academia Sinica, Guangzhou, for identifying the host plants.

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OCCURRENCE OF POWDERY MILDEW ON LACTUCA VIMINEA SUBSP. CHONDRILLIFLORA IN SOUTH FRANCE

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Abstract

During the summer 1999 an expedition was conducted in seven European countries to collect wild *Lactuca* spp. germplasm and to study its geographic distribution and ecology. Natural infections by powdery mildew were recorded to. *L. saligna* and *L. virosa* plants found in south France (Provence) were free of powdery mildew infections. However, powdery mildew on *L. viminea* subsp. *chondrilliflora* was found. Based on the observations of the morphology of its anamorph stage and comparison with the species described on *Lactuca* spp. till now, the identity of this powdery mildew species is discussed. The comparison of powdery mildew collected on *L. viminea* subsp. *chondrilliflora* with *Golovinomyces cichoracearum* (≡ *Erysiphe cichoracearum*), the only species hitherto described on *Lactuca* spp., showed substantial differences in length of conidia and their shape index, conidiogenesis and number of distal conidial cells (Pseudoidium type). The occurrence of cleistothecia was not recorded. The fungus may be assigned to *Erysiphe* emend., and is probably a new species.

Key words: *Erysiphe*, France

Introduction

Powdery mildews are very common on members of the Asteraceae (Braun 1987, 1995), however there is rather limited information on the geographic distribution of powdery mildew on *Lactuca* spp. (Lebeda 1999). Powdery mildew species have been described on *L. muralis, L. perennis, L. quercina, L. saligna, L. sativa, L. serriola, L. sibirica, L. viminea* and *L. virosa* (Lebeda 1985a,b, Braun 1995, Lebeda 1999). Until now, details about the natural distribution of powdery mildew are only available for *L. serriola* (Lebeda 1999). Only one species of powdery mildew, viz. *Golovinomyces cichoracearum* (DC.) V.P. Gelyuta (≡ *Erysiphe cichoracearum* DC.) has been recently

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described on *Lactuca* spp. (Lebeda 1985a, Braun 1995, Lebeda 1999). There is no significant variation in anamorph morphology on *Lactuca sativa* and wild *Lactuca* spp. (Lebeda 1985a, 1999). Occurrence of cleistothecia on *Lactuca* spp. is well documented only in the Czech Republic (Lebeda 1994, Lebeda and Buczkowski 1986).

Field observations

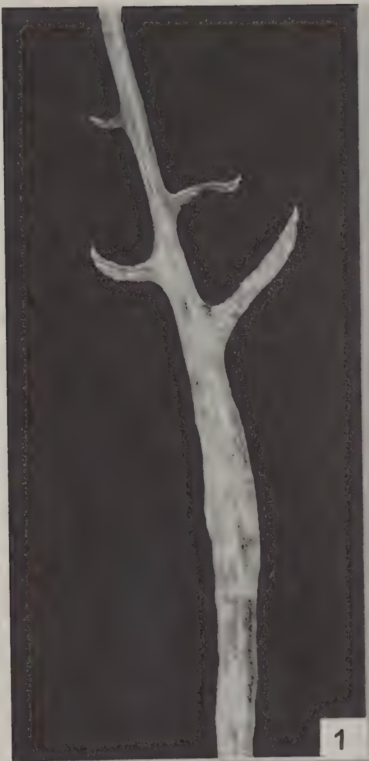
During summer 1999, the occurrence of *Lactuca* species was examined in seven European countries with the aim of studying their geographic distribution, ecology and biodiversity (Lebeda et al. 2001). Natural infections of powdery mildew and downy mildew (*Bremia lactucae*) on some wild *Lactuca* spp. were screened. In the Provence (south France) six sites with *Lactuca viminea* subsp. *chondrilliflora* occurrence were visited, but only in one location (Avignon) powdery mildew was observed on this species and subspecies respectively (Lebeda et al. 2001). This is the first report (Braun 1995) of powdery mildew on *L. viminea* subsp. *chondrilliflora* (Fig. 1) in Mediterranean area, France and probably in Europe. The distribution area of *L. viminea* subsp. *chondrilliflora* in comparison with that of the typical subspecies is rather small and comprises the southernmost regions of France, namely the Rhône valley and border area of France and Italy, the Pyrenées, Corbiéres and Cevennes Mts., Spain, Portugal, Serbia, Switzerland (Feráková 1977, Lebeda et al. 2002).

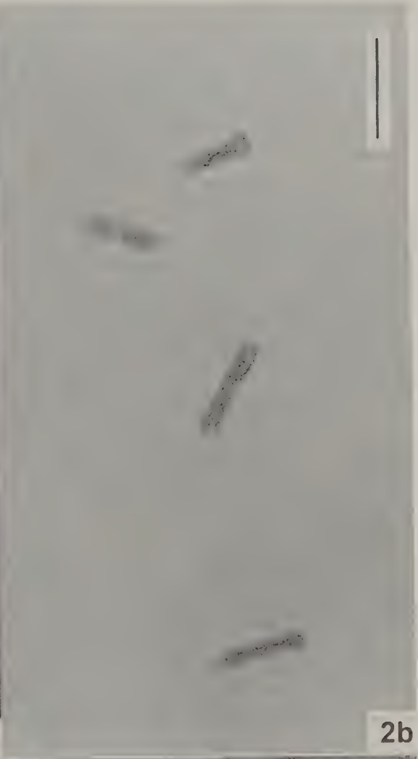
Microscopic evaluation

Two collected samples (PM1 and PM2) of powdery mildew (Fig. 1) were microscopically examined. One hundred conidia and 50 conidiophores and mycelial cells were evaluated from each sample. Conidia were formed singly, were cylindrical, did not contain fibrosin bodies (Fig. 2a,b), which are characteristic for *Podosphaera* Kunze, incl. *Sphaerotheca* Lév., and measured 36.6-61 µm in length (mean 46.4 µm), 9.8-13.4 µm in width (mean 11.3 µm), with a L/W ratio (shape index) was between 3-5.25 µm (mean 4.15 µm). Conidiophores were erect, foot-cells were followed by 2-4 distal cells. However both collected powdery mildew samples collected differed in the length of the foot-cells and in the total length of the conidiophores. The foot-cells were straight, and their length varied between 41.48 and 114.68 µm (mean 71.57 µm) for PM1 sample and from 61 to 156.2 µm (mean 112.4 µm) for PM2 sample. The width of the foot-cell width was between 6 and 9 µm (mean 7.35 µm) for both samples. The total length of the conidiophores was 100.1-170.8 µm (mean 137.4 µm) for PM1 sample and between 119.6-217.2 µm (mean 168.7 µm) for PM2. Cleistothecia were not observed.

Discussion

In the family Asteraceae, the best documented powdery mildew is *Erysiphe cichoracearum* DC. s.str. (Dixon 1978, Braun 1995), now assigned to *Golovinomyces* V.P. Gelyuta (Braun 1999), based on molecular examinations. Although there are reports on spontaneous occurrence of *G. cichoracearum* on *L. viminea* (Braun 1995) in Austria and in the European part of the former Soviet Union (Ukraine), in field screenings of wild *Lactuca* species for resistance to *G. cichoracearum* (Lebeda 1994), there were no symptoms of infection recorded on *L. viminea* accessions. This may have resulted from *E. cichoracearum* s.str. consisting of several biologically different strains (Dixon 1978).





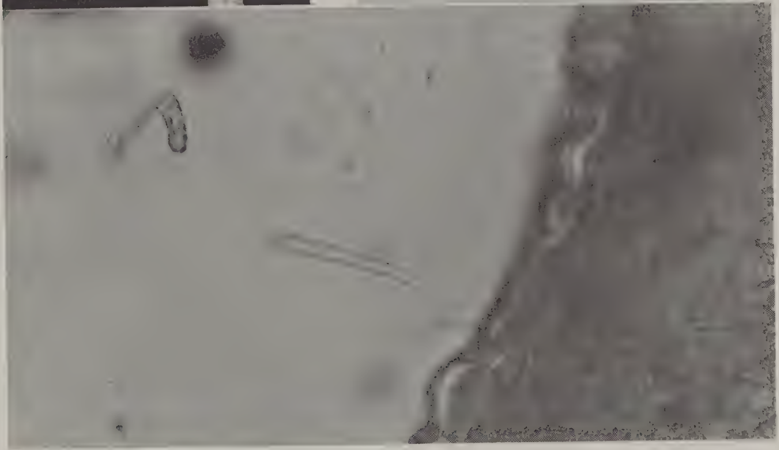


Fig. 1. Symptoms of powdery mildew (*Erysiphe* emend.) on *Lactuca viminea* subsp. *chondrilliflora*

Fig. 2. Powdery mildew on *Lactuca viminea* subsp. *chondrilliflora*
(a) conidiophore, (b) conidia (Bar = 50 μm)

However, a comparison of morphological characteristics of three anamorphs of powdery mildew collected on *L. viminea* subsp. *chondrilliflora* with *G. cichoracearum* (Table 1) clearly demonstrates differences mainly in the length of conidia and thus shape index, in conidiogenesis and number of distal conidial cells of both powdery mildews. The shape index of powdery mildew on *L. viminea* subsp. *chondrilliflora* exceeded 3, while for *G. cichoracearum* the shape index did not reach more than 2.3 (Table 1). The number of distal conidial cells was between 4-6 (formed in short chains – Euoidium type) for *G. cichoracearum*, and 2-4 (formed singly - Pseudoidium type) for powdery mildew on *L. viminea* subsp. *chondrilliflora* (Table 1, Fig. 2a). Although the host range of *G. cichoracearum* included *L. viminea*, it can be excluded that both powdery mildew samples belong to the same species. This hypothesis could be supported by the new taxonomy of powdery mildews, where anamorphs play an increasingly important role (mainly conidia arrangement) (Braun and Takamatsu 2000), which has recently been confirmed by SEM examinations (Cook et al. 1997) and molecular data (Takamatsu et al. 1998, Saenz et al. 1999, Mori et al. 2000).

TABLE 1. Basic anamorphic characters of powdery mildews reported on *Lactuca* species

	Origin of powdery mildew				
Characteristics (mean ± SD, (range))	*L. viminea* subsp. *chondrilliflora* (both isolates, recent results)	*L. serriola* (Lebeda and Mieslerová 2000, Lebeda et al. 2002)	Wild *Lactuca* spp. (Lebeda 1985a)	*Lactuca sativa* cvs. (Lebeda 1985a)	Description of *E. cichoracearum* var. *cichoracearum* (Braun 1987)
Conidia					
Length (µm)	46.4 ± 5.02 (36.6 – 61.0)	28.60± 2.08 (21.28 – 35.36)	28.72	29.35	(25 – 42)
Width (µm)	11.3 ± 1.25 (9.8 – 13.4)	12.78 ± 1.02 (10.02 – 14.68)	13.70	13.98	(14 – 22)
L/W ratio	4.15 ± 0.67 (3 – 5.25)	2.25 ± 0.27 (1.88 – 2.5)	2.09	2.10	Around 2
Fibrosin bodies	No	No	No	No	No
Conidiogenesis	Singly	In chains	In chains	In chains	In chains
Conidiophores					
Length (µm)	152.6 ± 29.59 (100.1– 217.2)	132.60 ± 13.69 (102.48 – 153.72)	-	-	-
Foot-cell length (µm)	91.9 ± 25.36 (41.48 – 156.2)	50.06 ± 10.09 (35.36 – 68.52)	-	-	(40 – 140) mostly 50 - 80
Number of distal cell	3.00 ± 1.07 (2 – 4)	5.00 ± 0.59 (4 – 6)	-	-	(1 – 3)

Besides *G. cichoracearum*, the occurrence of other species of genus *Erysiphe* DC. (s.lat.), *Podosphaera* (incl. *Sphaerotheca* spp.) and *Leveillula taurica* has been reported on hosts of the Asteraceae (Braun 1995), but all of them differ from the powdery mildew on *L. viminea* subsp. *chondrilliflora*. However, *Erysiphe* s.lat. according to Braun (1995) included both species with pseudoidium and euoidium anamorph. None of the *Erysiphe* spp. with similar pseudoidium anamorph occurring on the Asteraceae was described on *Lactuca* spp. *Erysiphe mayorii* S. Blumer var. *cicerbitae* U. Braun (1995) is known from Europe on *Cicerbita alpina, C. macrophylla* (≡ *Mulgedium cacaliifolium*) and *C. plumieri*. *Cicerbita* and *Lactuca* are two related genera, but the anamorph of *E. mayorii* var. *cicerbitae* is quite distinct from the powdery mildew on *Lactuca viminea* subsp. *chondrilliflora*. The conidia are much shorter and wider (23-35 x (11-)14-21 µm). Due to the absence of a teleomorph, it is not possible to be completely certain about the identification of powdery mildew on *L. viminea* subsp. *chondrilliflora*. Nevertheless, there is a strong probability that it represents a new species.

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PYRENOPEZIZA DORONICI SP. NOV. FROM BULGARIA

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Abstract

Pyrenopeziza doronici on *Doronicum* sp. from Bulgaria is described and illustrated as a new species.

Keywords: discomycetes, Helotiales, taxonomy, Bulgaria.

The representatives of *Pyrenopeziza* Fuckel are wide- spread in nature. A good basis for Bulgarian members has been presented by Baral & Krieglsteiner (1985), Breitenbach & Kränzlin (1981), Dennis (1978), Gremmen (1958), Huetter (1958), and Nannfeldt (1932).

In the author's investigations on the Bulgarian discomycete flora, a new species of *Pyrenopeziza* was collected on *Doronicum* sp. The specimen is deposited in the Mycological Collection of the Institute of Botany (SOMF).

Pyrenopeziza doronici **E.G. Dimitrova, sp. nov.** **Figs. 1-2**

Apothecia erumpentia, sessilia, sparsa vel gregaria, primo subglobosa, postea patelliformia, 0.2-0.8 mm diametro, nigrofusca, margo albidogriseus sine pilis distinctis, hymenium griseum. **Excipulum ectalum** ex textura globulosa compositum, cellulae 7.5-12.5 µm diametro, parietes tenues, brunnei. **Asci** 31.5-42.5 x 4-5.5 µm, breviter clavati, apex angustatus poro parvo, porus ab iodo caerulescens, octospori. **Ascosporae** 7-8 x 2-2.5 µm, fusiforme-clavatae, aseptatae, obliquae, uniseriales vel biseriales, hyalinae. **Paraphyses** simplices, filiformes, apice obtuso, 2-2.5 µm lato, aseptatae, ascos non superantes, hyalinae.

Holotypus: Ad caules siccos *Doronici* sp., Bulgaria, Mons Rila, loco dicto "Borovetz", 1346 m alt., 22.VI.1995, leg. E.G. Dimitrova, SOMF 22 193.

Apothecia erumpent, sessile, scattered or in small groups, first subglobose, later patellate, 0.2-0.8 mm in diam., blackish-brown with a whitish-gray margin without distinct hairs, and gray hymenium. **Ectal excipulum** composed of textura globulosa, cells 7.5-12.5 µm in diam. with thin brown walls. **Asci** (31.5-) $\overline{X}$ =39.13; SD=2.20 (-42.5) x (4-)$\overline{X}$=4.97; SD=0.22 (-5.5) µm (N=30), short clavate, apex narrowed with a small pore, blued by iodine, 8-spored. **Ascospores** (7-) $\overline{X}=7.59$; SD=0.62 (-8) x (2-) $\overline{X}=2.04$; SD=0.14 (-2.5) μm (N=50), fusiform-clavate, aseptate, obliquely, uniseriate or biseriate in the ascus, hyaline. **Paraphyses** simple, filiform, apex obtuse, 2-2.5 μm wide, aseptate, not exceeding the asci, hyaline.

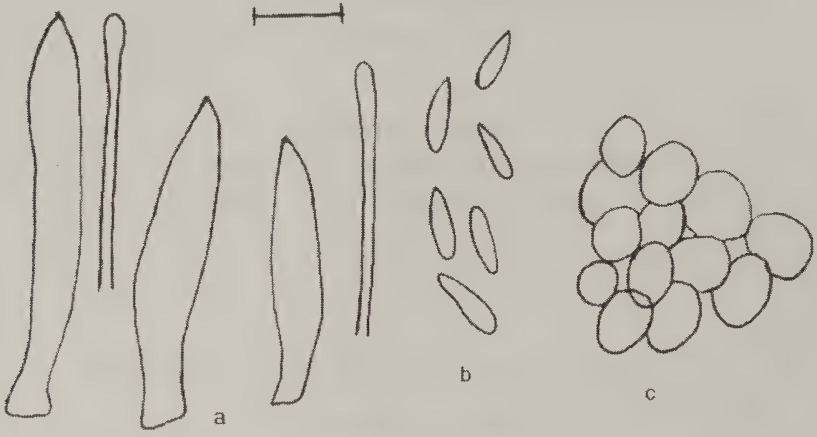

Fig. 1. ***Pyrenopeziza doronici*: a) asci and paraphyses; b) ascospores; c) excipulum. Scale bar 10 μm.**

On dry stems of *Doronicum* sp., Rila Mountain, Borovetz locality, 1346 m alt., 22.VI.1995, E.G. Dimitrova, SOMF 22 193 (holotype).

Pyrenopeziza doronici resembles *P. escharodes* (Berk. & Br.) Rehm (Breitenbach & Kränzlin, 1981: 230). However, these two species are easily distinguished on the bases of the paraphyses, margin and substrata (Table I).

ACKNOWLEDGEMENTS

My thanks to Dr T. Hosoya for reviewing the manuscript and making helpful suggestions. I'm grateful to Dr C. Denchev kindly corrected the latin diagnosis and Mr B. Assyov for the photograph.

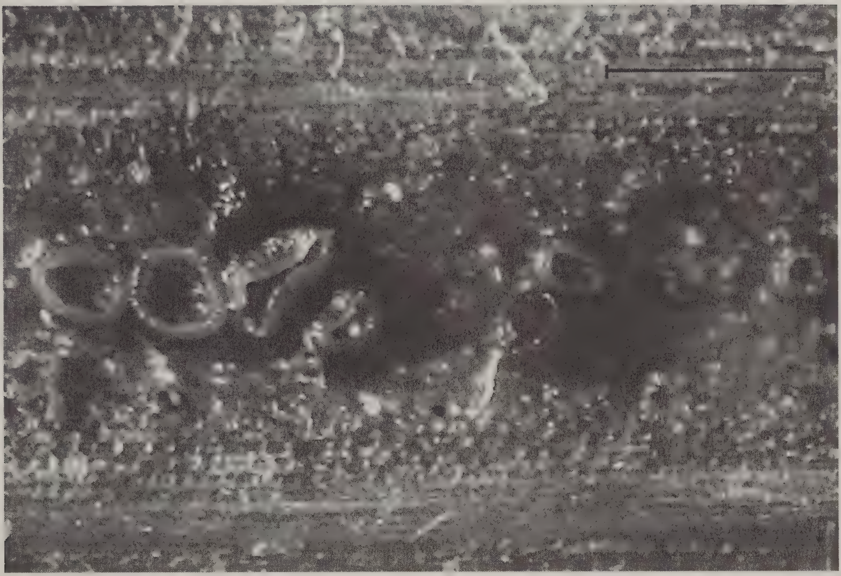

Fig. 2. *Pyrenopeziza doronici*: Apothecia (rehydrated). Scale bar 1 mm.

Species	Asci (µm)	Ascospores (µm)	Margin	Paraphyses	Substratum
Pyrenopeziza doronici	31.5 - 42.5 x 4 - 5.5, apex J $^+$	7 - 8 x 2 - 2.5	without distinct hairs, whitish gray	aseptate, apices simple	*Doronicum* sp.
Pyrenopeziza escharodes (according to Breitenbach & Kränzlin, 1981)	38 - 48 x 5 - 6.5, apex J $^+$	7 - 9 x 2 - 2.5	hairy, with brown, 2-3-septate hairs	septate, apices forked	*Rubus* sp.

Table 1. Comparison of *Pyrenopeziza doronici* and *P. escharodes*

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RELATIONSHIPS BETWEEN AUSTRALIAN AND NORTHERN HEMISPHERE GYMNOPILUS SPECIES II. A PRELIMINARY PHYLOGENY OF SPECIES OF GYMNOPILUS AND RELATED GENERA BASED ON INTERNAL TRANSCRIBED SPACER (ITS) REGION OF RIBOSOMAL DNA

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ABSTRACT

Sequences from the Internal Transcribed Spacer (ITS) region of ribosomal DNA were used to generate a phylogeny for 30 Australian and Northern Hemisphere species of the saprotrophic genus *Gymnopilus* and related genera, currently included in the Cortinariaceae. Groupings of Northern and Southern Hemisphere species emerge which support morphological findings. Evidence strongly supports the uniqueness of all but one Australian species of this saprotrophic genus, *Gymnopilus junonius*, while also indicating relatedness to Northern Hemisphere species. *Gymnopilus* is only monophyletic when it includes *Galerina eucalyptorum* and *Pyrrhoglossum pyrrhum* - the type species of *Pyrrhoglossum*. Morphological and chemical evidence supports the incorporation of these two species into *Gymnopilus* as *G. anomalus* nom. nov. and *Gymnopilus pyrrhum* comb. nov. respectively. Molecular evidence also strongly supports the retention of *Gymnopilus penetrans* and *Gymnopilus hybridus* as separate species from *Gymnopilus sapineus* as described by Orton (1993).

Key words: Agaricales, Cortinariaceae, *Phaeocollybia*, *Pyrrhoglossum*

INTRODUCTION

In a study of the Australian species of *Gymnopilus* P.Karsten, *Pyrrhoglossum* Singer and *Phaeocollybia* Heim (Rees 1996), 40 species of *Gymnopilus* were described, many of which closely resembled Northern Hemisphere species and have often been named after them in the Australian literature. These species have been re-identified, and their relation to overseas species examined (Rees & Strid 2001). With their predominantly yellow to brown appearance with rust-coloured overtones, many species of *Gymnopilus* look remarkably similar in the field and identification relies heavily on microscopic characters such as basidiospore size, shape and ornamentation, and on variation in the size, shape and location of cystidia. Many conflicting descriptions of Northern Hemisphere *Gymnopilus* species are due either to the variable appearance of macroscopic characters, or to the versiform nature of cystidia. Species with distinctive morphological characters, for example *Gymnopilus sapineus* (Fr.) Maire, *G. penetrans* (Fr.) Murrill and *G. hybridus* (Fr.) Maire (Orton 1993) can be remarkably similar microscopically, resulting in their synonymisation under one name, in this case *G. sapineus* (Høiland 1990). The lack of type material for many of these early Friesian species has not helped with their identification.

Although over 200 species of *Gymnopilus* have been described worldwide, there are few infrageneric classifications. Those used to date have been based on the presence or absence of a membranous annulus (Singer 1951, Kühner & Romagnesi 1959) and on basidiospore size (Hesler 1969, Guzmán-Dávalos 1995). Doubt has been cast on the "naturalness" of some of these groupings (Rees & Ye 1999). In the most recent treatment of *Gymnopilus* species occurring in Great Britain, Orton (1993) has proposed eight stirps in two sections, based on 'features which set them aside from others'.

The limits of the genus *Gymnopilus* were described by Singer (1986) in relation to three other saprotrophic members of the Tribus Cortinarieae - *Galerina* Earle, *Pyrrhoglossum* and *Phaeocollybia*. Subsequent studies have demonstrated that the generic limits between *Gymnopilus* and *Galerina* species based on presence or absence of a plage, reaction of the carpophore and stipe surfaces with KOH, and the presence or absence of styrylpyrone pigments are more variable than previously supposed (Rees & Ye 1999, Rees *et al.* 1999). The description of several small-statured, excentrically stipitate *Galerina* species (Horak 1987) with *Gymnopilus*-like microscopic characters, but lacking styrylpyrone pigments, has further blurred the distinction between the two genera (Rees & Ye 1999). *Pyrrhoglossum* was originally segregated from *Gymnopilus* on the basis of its consistently pleurotoid habit despite the many similarities in spore wall structure, pileus structure and the production of diffusing, yellow pigment (Singer 1944). Relationships between *Pyrrhoglossum* and *Gymnopilus* species have been explored extensively (Horak 1989; Rees and Ye 1999) with Horak regarding *Pyrrhoglossum* as being more closely related to *Phaeocollybia* on a morphological basis, despite the lignicolous habit of *Pyrrhoglossum*. Some members of *Phaeocollybia* have since been demonstrated to form mycorrhizal associations (Norvell

2000), suggestive of a closer relationship with ectomycorrhizal genera within the family.

The differentiation of Australian *Gymnopilus* species from similar, poorly defined European species on a morphological basis has not been simple. The nature of the relationships of these Australian species with *Gymnopilus sapineus* sensu Høiland and *Gymnopilus picreus* (Fr.) P. Karsten (species after which so many Australian collections are named), warranted further investigation. The Internal Transcibed Spacer region (ITS) of nuclear ribosomal DNA (rDNA) has been used to examine relationships in the mycorrhizal genus *Cortinarius* (Liu et al. 1997, Høiland & Holst-Jensen 2000, Seidl 2000) and saprotrophic *Galerina* (Gulden et al. 2001), all of which have been included in Tribus Cortinarieae by Singer (1986) on the basis of their spore wall structure and ornamentation. The only species of *Gymnopilus* for which ITS sequence data were published was *G. sapineus* from Norway when it was used as outgroup for a phylogenetic analysis of *Cortinarius* and *Dermocybe* species (Høiland & Holst-Jensen 2000).

An analysis of the ITS region of nuclear rDNA was undertaken from a wide variety of species of *Gymnopilus* from Australia, Europe and N. America. The main aims of the project were (i) to determine the relationships between Northern and Southern Hemisphere morphologically similar *Gymnopilus* species and (ii) to infer an intergeneric phylogeny of *Gymnopilus* using closely related genera, such as *Phaeocollybia, Pyrrhoglossum* and *Galerina.* As the European material should represent as closely as possible the Friesian concept of these species, collections made in the Femsjö area of Southern Sweden where Fries did so much of his early collecting were kindly lent by Prof. Dr M. Moser for comparison with Australian material. These included all three species synonymised by Høiland under *Gymnopilus sapineus* namely *Gymnopilus penetrans*, *Gymnopilus hybridus*, and two collections of *Gymnopilus sapineus*, one of which had dark-coloured pigment at the disc. In addition *Gymnopilus picreus* (Fr.) P.Karsten and a diminutive collection labelled *Gymnopilus spectabilis* var. *junonius* occurring on fallen *Betula* branches were examined. *Agaricus junonius* was first described by Fries from “rotting trunks” as, "solitary, small, beautiful and rare with a glabrous pileus surface", in contrast to the much more robust species *A. spectabilis* which he also described seven years later as commonly occurring on *Quercus* roots. Despite their different appearance, both species have been reduced to synonymy under *G. junonius* by Orton (1960). The majority of *G. junonius* collections commonly found in Australia and Northern Europe are caespitose and of robust stature, although more slender fruit bodies do occur in developing stages on plant roots. They have commonly been called *Gymnopilus pampeanus* (Speg.) Singer in Australia, although the type of that species from S. America is diminutive, with no obvious surface scales and was not originally described in association with *Eucalyptus*.

Table 1. Identity and location of collections examined.

Species name	Identity	Location	GenBank No.
Gymnopilus			
G. *allantopus*(Berk.)Pegler	BRWA 99/7b	Glen Eagles, WA, AUS	AF 501542
G. *allochrous* nom.prov.	UNSW 93/16	Mt. Wilson, NSW, AUS	AF 501543
G. *austropicreus* B.J.Rees	BRV 99/4	Marysville, Vic, AUS	AF 501544
G. *crociphyllus* (Cke. & Mass.)Pegler	UNSW 98/34	Audley, NSW, AUS	AF 501545
G. *eucalyptorum* (Cleland)Singer	BRV 99/10	Marysville, Vic, AUS	AF 501546
G. *ferruginosus* B.J.Rees	BRV 99/5	Marysville, Vic, AUS	AF 501547
G. *hybridus* (Fr.)Maire	IB 78/226	Femsjö, SWEDEN	AF 501548
G. *junonius*(Fr.)P.D.Orton	AS 25690	Vittlycke, SWEDEN	AF 501549
G. *luteofolius*(Peck)Murrill	JFA 12367	Shelton, Washington, USA	AF 501550
G. *moabus* Grgur.	UNSW 99/38	Audley, NSW, AUS	AF 501551
G. *mullaunius* Grgur.	UNSW 99/35	Audley, NSW, AUS	AS 501552
G. *norfolkensis* B.J.Rees & Lepp	HL 1283	Norfolk Is. AUS (protect).	AS 501553
G. *pampeanus* (Speg.)Singer	BRV 99/1	Yarra Ranges, Vic. AUS	AS 501554
G. *patriae* B.J.Rees	UNSW 01/4	Audley, NSW, AUS	AF 501555
G. *penetrans*(Fr.)Murrill	BRGB 98/5	Pitlochry, SCOTLAND	AF 501556
G. *picreus*(Fr.)P. Karsten	AS 97/103	Karl-Ols, SWEDEN	AF 501557
G. *rimosus* nom. prov.	KS 803/95	Denmark, WA, AUS	AS 551558
G. *sapineus* (Fr.)Maire (1)	IB 78/154	Femsjö, SWEDEN	AF 501559
G. *sapineus* (Fr.)Maire (2)	IB 78/225	Femsjö, SWEDEN	AF 501560
G. *sapineus* sensu Høiland	-	Buskerud, NORWAY	AJ 236079
G. *spectabilis* (Fr.)A.H.Smith var *junonius* Kühner & Romagn.	IB 70/320	Bremen, GERMANY	AF 501561
G. *tyallus* Grgur.	UNSW 99/33	Audley, NSW, AUS	AF 501562

Species name	Identity	Location	GenBank No.
Galerina			
Gal. eucalyptorum E.Horak	BRWA 99/5	Perth, WA, AUS	AF 501563
Gal. marginata(Batsch)Kühner	UNSW99/11	Mt. Wilson, NSW, AUS	AF 501564
Gal. nana(Petri)Kühner	O 72373	Benton, Or, USA	AF 251184
Gal. pseudocerina A.H.Smith & Singer	O 70336	Eyjafjar∂arsysla Co, Iceland	AF 251182
Gal. pseudomycenopsis Pilát	O 70471	S-Mulasysla Co, Iceland	AF 251177
Gal. subcerina A.H.Smith & Singer	UNSW 99/31	Jenolan Caves, NSW, AUS	AF 501565
Gal. tibiiformis A.E.Wood	UNSW 00/09	Jindabyne, NSW, AUS	AF 501566
Phaeocollybia			
Ph. graveolens B.J.Rees & Syme	KS 880/96	Denmark, WA, AUS	AF 501567
Ph. ratticauda E.Horak	BRV 99/11	Marysville, Vic, AUS	AF 501568
Pyrrhoglossum			
P. pyrrhum(Berk.& M.A.Curtis)Singer	UNSW 86/88	Dorrigo, NSW, AUS	AF 501569
Cortinarius			
C. pholideus (Fr.)Fr.	no information	Oslo, NORWAY	AJ 236072

MATERIALS AND METHODS

Sequences from 22 samples of *Gymnopilus* species and 11 samples of related genera were used for deciphering relationships within the group. *Gymnopilus* collections comprised 13 from Australia, 8 from Europe and one from N. America. DNA was extracted using fresh and dried specimens, and in some instances, cultures grown from spore prints of exotic species. Collections with the most complete sequences were used for the analysis although in some cases, up to five separate collections were sequenced for each species. These were supplemented with data from GenBank for comparison with Northern Hemisphere species where appropriate (Table 1).

DNA Extraction

DNA was extracted in CTAB buffer using the following procedure. Tissue (approximately 10-50 mg) was ground in microfuge tubes in extraction buffer (2% CTAB, 0.1 M Tris-HCl (pH 8.0), 1.4 M NaCl, 0.02M EDTA, 1% PEG 8000. Samples were then placed in a waterbath at 65°C for 30 min. mixing occasionally. Samples were spun for 10 min. at 12K G and then extracted with an equal volume of phenol:chloroform:isoamyl alcohol (25:24:1), mixed and spun again for 10 min. The aqueous phase was then extracted with an equal volume of chloroform:isoamyl alcohol (24:1), spun, and the aqueous phase removed to a fresh microfuge tube. An equal volume of 100% isopropanol was added, the tube inverted several times and placed at room temperature for 30 min. The sample was centrifuged for 30 min. at 12K G and decanted. The DNA pellet was washed in 70% ethanol, air-dried and 50 μl of TE buffer was added. 1 μl of DNase-free RNase A was added and the sample incubated at 37°C for 15 min. The sample was then frozen until use.

ITS amplification

Amplification primers for ITS-1, ITS-2, ITS-3, ITS-4 and ITS-5 (White et al. 1990) were used to sequence nuclear rDNA which comprised the ITS 1, 5.8S and ITS 2 region. Reaction conditions in the 50μl final volume were: 1X PCR buffer (Promega™ Buffer A), 250 nM dNTP's, 2.5 mM $MgCl_2$, 15 pmol of each primer, and 1U Taq DNA polymerase (Promega™). A touchdown PCR procedure was used for amplification, consisting of an initial denaturation at 95°C for 5 min followed by 10 cycles of denaturing at 94°C for one min, annealing at 60°C for one min, with reduction in annealing temperature by one degree C each cycle until 50°C, and extension at 72°C for one min. This touchdown was then followed by 24 cycles of 89/50/72°C for 1 min. each and a final 10 min. 72°C extension. PCR products were purified with Wizard PCR Preps (Promega ™) and then quantified after electrophoresis in 1% agarose in TAE buffer by comparison with molecular markers of known concentration.

Automated sequencing was performed (using the amplification primers plus internal primers) on an ABI Prism 377 DNA Sequencer™ (Perkin-Elmer) after cycle sequencing of the purified PCR product with ABI Prism© Big Dye™ Terminator Cycle Sequencing Reaction Kit. Samples were prepared for electrophoresis by ethanol precipitation following the manufacturer's recommendations. Sequences were assembled using the computer program Auto Assembler. Sequences were aligned with Clustal X (Thompson et al. 1997) and refined by eye. Phylogenetic relationships were inferred with PAUP* (Swofford 2001). In all analyses gaps were considered as missing data. Trees were rooted using the outgroup taxon *Cortinarius pholideus* which lies outside, but close to a clade containing *Gymnopilus* in a preliminary analysis based on the 28S region of rDNA (unpublished data).

Maximum parsimony trees were constructed in PAUP*, with a heuristic search of 500 replicates of random sequence additions and using TBR branch swapping. Distance trees were constructed using Kimura-2 parameter estimate of distance and neighbour-joining reconstruction. Maximum likelihood was also used to construct the most likely tree from the data set (five random additions). Maximum-likelihood parameters were estimated using the maximum-likelihood ratio test. The programme Modeltest version 3.0 (Posada & Crandall 1998) was used to find the model of sequence evolution that best fitted the data set by a hierarchical likelihood ratio test ($\alpha = 0.05$). When the best sequence evolution model was determined, maximum-likelihood tree searches were performed in PAUP* using the estimated parameters (gamma distribution, proportion of invariable sites, rate matrix).

Support for individual internal branches was determined using bootstrap analysis (Felsenstein 1985) as implemented in PAUP* using a decay index (Donoghue *et al.* 1992). For bootstrap analysis, 500 bootstrap data sets were generated from resampled data (five random sequence additions) using parsimony criteria. Decay indices, on a strict consensus of most parsimonius trees, were calculated with AutoDecay version 4.0.2 (Eriksson 1998). All sequences are deposited at GenBank (see Table 1).

RESULTS

The aligned ITS data set consisted of 773 aligned positions with 223 parsimony-informative characters. Maximum parsimony analysis produced 60 trees of 997 steps (CI = 0.5787, RI = 0.5195). The strict consensus topology is presented in Fig. 1. Modeltest determined the model of sequence evolution that best fitted the data set to be the general time-reversible substitution model with proportion of invariable sites (=0.3804) and a gamma distribution of 0.7661. The topology of this tree (likelihood score = 5385.9301) is shown in Fig. 2. The two trees show a high degree of

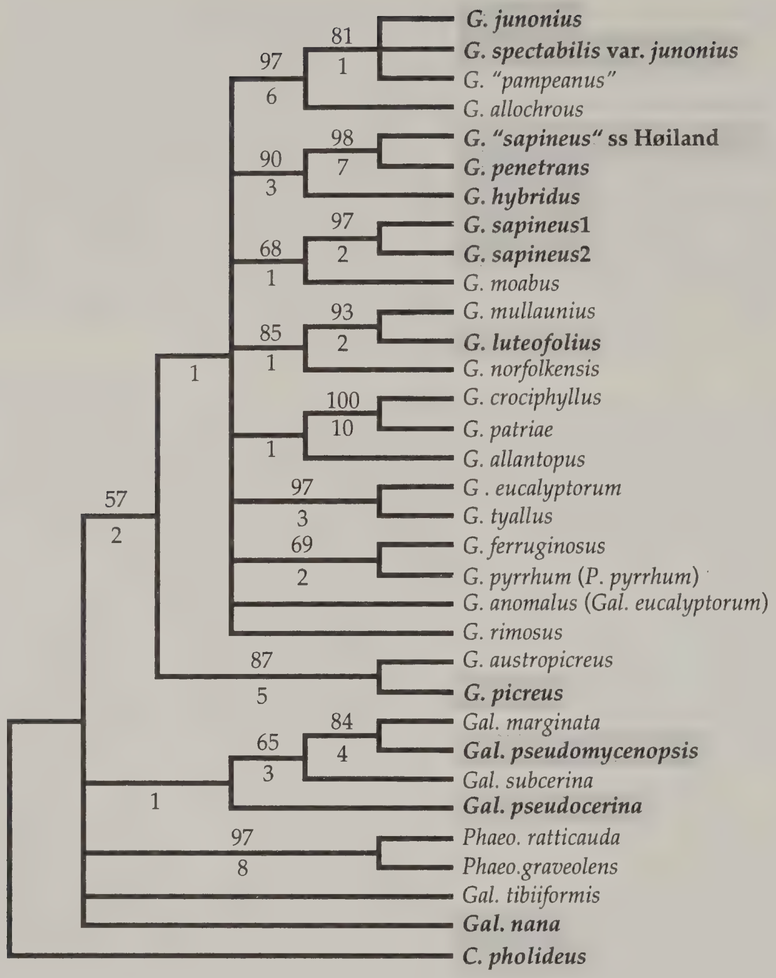
G. junonius
G. spectabilis var. junonius
G. "pampeanus"
G. allochrous
G. "sapineus" ss Høiland
G. penetrans
G. hybridus
G. sapineus1
G. sapineus2
G. moabus
G. mullaunius
G. luteofolius
G. norfolkensis
G. crociphyllus
G. patriae
G. allantopus
G . eucalyptorum
G. tyallus
G. ferruginosus
G. pyrrhum (P. pyrrhum)
G. anomalus (Gal. eucalyptorum)
G. rimosus
G. austropicreus
G. picreus
Gal. marginata
Gal. pseudomycenopsis
Gal. subcerina
Gal. pseudocerina
Phaeo. ratticauda
Phaeo.graveolens
Gal. tibiiformis
Gal. nana
C. pholideus
81
1
97
6
98
7
90
3
97
2
68
1
93
2
85
1
1
100
10
1
97
3
69
2
57
2
87
5
84
4
65
3
1
97
8

Fig. 1. Phylogeny of selected *Gymnopilus* species and related genera based on aligned ITS DNA sequence data. Topology of strict consensus parsimony tree (60 trees, 997 steps; CI= 0.5787). Parsimony-derived bootstrap values (500 replicates, 5 random additions) above branches. Decay values below branches. Shading indicates Northern Hemisphere collections.

congruence and will be described together, indicating differences where they exist.

The maximum parsimony tree has a basal polytomy containing *Galerina nana*, G. *tibiiformis*, a well supported clade comprising the two *Phaeocollybia* species (*P. graveolens* and *P. ratticauda*) and a poorly supported clade containing the remaining *Galerina* species. The grouping of the *Phaeocollybia* species is strongly supported by bootstrap and decay analysis and is on a relatively long branch in the maximum likelihood analysis. The relationship of the *Phaeocollybia* species to other genera is poorly resolved in the parsimony analysis, but in the maximum likelihood analysis is basal to the clade containing all *Galerina* and all *Gymnopilus* species. The remaining taxa are resolved into two groups. In the parsimony analysis, four *Galerina* species, *G. marginata, G. pseudomycenopsis, G. subcerina* and *G. pseudocerina* are monophyletic, albeit with only marginal support from the decay analysis. Within this clade, the Northern Hemisphere *Galerina marginata* and *G. pseudomycenopsis* are sister taxa with good branch support and *G. subcerina* and *G. pseudocerina* as sister taxa. In the maximum likelihood tree *Galerina nana* forms a clade with *G. marginata, G. pseudomycenopsis* and *G. pseudocerina* while the two Australian collections G. *tibiiformis* and *G. subcerina* are less closely related.

Within the *Gymnopilus* clade, *G. picreus* and *G. austropicreus* are basal to the rest of the *Gymnopilus* species in both trees. The monophyly of *G. picreus* and *G. austropicreus* is well supported by bootstrap and decay analysis, but the separation of these two species from the remaining *Gymnopilus* species is only weakly supported by decay analysis. In the parsimony analysis, the remaining 22 taxa form a polytomy in which seven clades and two unresolved taxa including 20 *Gymnopilus* collections, *Galerina eucalyptorum* and *Pyrrhoglossum pyrrhum* are found. The positions of *Gymnopilus rimosus* and *Galerina eucalyptorum* are unresolved. *Pyrrhoglossum pyrrhum* and *Gymnopilus ferruginosus* are sister taxa with moderate bootstrap and low decay support. *Gymnopilus eucalyptorum* and *G. tyallus* are sister taxa with good support. *Gymnopilus crociphyllus, G. patriae* and *G. allantopus* also form a monophyletic group although the position of *G. allantopus* is poorly supported at the base. *Gymnopilus mullaunius, G. luteofolius* and *G. norfolkensis* also form a monophyletic, well supported group. The two collections of *Gymnopilus sapineus* from Femsjö, Sweden form a clade with *Gymnopilus moabus* from Australia, whereas a collection identified as *Gymnopilus sapineus* from Norway is in a clade with *Gymnopilus penetrans* and *Gymnopilus hybridus*. A final clade of four taxa is strongly supported and comprises the Australian *Gymnopilus allochrous* at the base and a polytomy of *Gymnopilus junonius* from Sweden, *Gymnopilus spectabilis* var. *junonius* from Germany and *Gymnopilus pampeanus* from Australia.

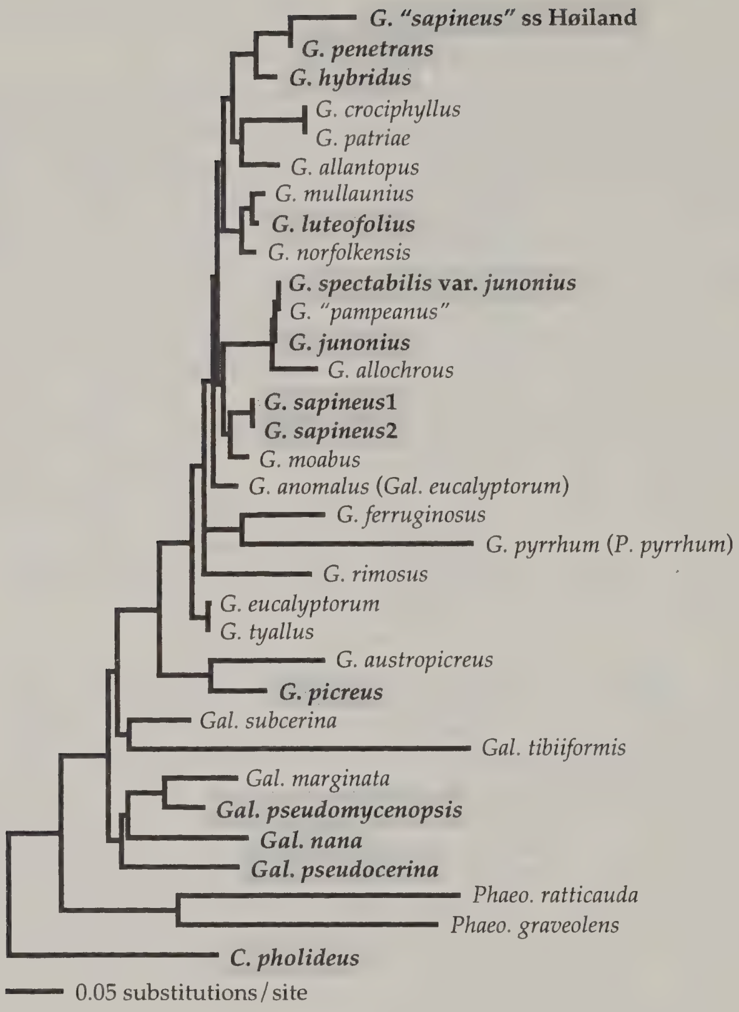
G. "sapineus" ss Høiland
G. penetrans
G. hybridus
G. crociphyllus
G. patriae
G. allantopus
G. mullaunius
G. luteofolius
G. norfolkensis
G. spectabilis var. junonius
G. "pampeanus"
G. junonius
G. allochrous
G. sapineus1
G. sapineus2
G. moabus
G. anomalus (Gal. eucalyptorum)
G. ferruginosus
G. pyrrhum (P. pyrrhum)
G. rimosus
G. eucalyptorum
G. tyallus
G. austropicreus
G. picreus
Gal. subcerina
Gal. tibiiformis
Gal. marginata
Gal. pseudomycenopsis
Gal. nana
Gal. pseudocerina
Phaeo. ratticauda
Phaeo. graveolens
C. pholideus
0.05 substitutions/site

Fig. 2. Phylogeny of selected *Gymnopilus* species and related genera based on aligned ITS DNA sequence data. Maximum-likelihood topology, using Modeltest optimised parameters (likelihood score= 5385.9301). Shading indicates Northern Hemisphere collections.

DISCUSSION

The maximum likelihood analysis indicates that *Gymnopilus* and *Galerina* species form sister genera and that these two genera form a clade that is sister to *Phaeocollybia* although these clades are not strongly supported in the analysis. For *Gymnopilus* to be monophyletic, it should include *Galerina eucalyptorum* and *Pyrrhoglossum pyrrhum*. The case for recombining these species follows.

Galerina eucalyptorum E.Horak has distinctly gymnopiloid features (Rees *et al.* 1999), but was included in *Galerina* (Horak 1987) on the basis of its excentric stipe and lack of styrylpyrone pigments. Since that time, other *Gymnopilus* species have been described (Rees & Ye 1999) which also lack styrylpyrones. A species *Gymnopilus eucalyptorum* (Cleland) Grgur., distinct from *Galerina eucalyptorum* has already been described from Australia. It is very similar to *Galerina eucalyptorum* morphologically, but has a different suprapellis structure and has pigment in the lamella tissue. Thus *Galerina eucalyptorum* is here renamed *Gymnopilus anomalus* because the name *Gymnopilus eucalyptorum* is already occupied.

Pyrrhoglossum pyrrhum is the type species of the genus, and is a cosmopolitan species which occurs on the east coast of Australia. It was segregated on the basis of its pleurotoid habit at maturity, and contrary to claims by Horak (1989), it does produce yellow pigments which diffuse in KOH (Rees & Ye 1999). These may be styrylpyrones or their derivatives. *Pyrrhoglossum pyrrhum* also has many morphological and ecological features consistent with *Gymnopilus* such as pileipellis structure, basidiospore ornamentation and a lignicolous habit. It emerges in both strict parsimony and maximum likelihood analyses as most closely related to *Gymnopilus ferruginosus*. Both species have similar, heavily ornamented basidiospores but of a larger size in the case of *Gymnopilus ferruginosus* (Rees & Strid 2001). The species is on a long branch in parsimony analysis and it has obviously undergone significant evolutionary change, but its sequence still clearly has much in common with other *Gymnopilus* species. Molecular studies on other *Pyrrhoglossum* species would need to be undertaken before recombining all *Pyrrhoglossum* species with *Gymnopilus*, but *Pyrrhoglossum pyrrhum* is herewith recombined as *Gymnopilus pyrrhum*, reducing the type species of *Pyrrhoglossum* to synonymy with *G. pyrrhum*.

Both analyses support several groupings of *Gymnopilus* species. Some of these have strong bootstrap support and help resolve the affiliations of several of the Australian taxa. *Gymnopilus picreus* and *G. austropicreus* are the most basal members of *Gymnopilus* species sampled. Although bootstrap support is low, they continually come out basal to the remainder of the tree. Synapomorphies for this clade include an hygrophanous pileus, a persistent perispore and inflated pileocystidia (Rees & Strid 2001). Pigments in these two species appear to be more soluble in lipid droplets than in the KOH mounting fluid itself. Høiland (1990) has postulated that *G. picreus* may be the most ancestral of the *Gymnopilus* species on the basis of several morphological and ecological character states, and molecular data lends support to this hypothesis.

Three Australian collections of *Gymnopilus junonius*, a species which has been recorded consistently as *G. pampeanus* (Speg.) Singer from Australia, differ by only two base pairs from *G. junonius* collections from Sweden. This is the smallest degree of variation present in separate collections of the same species in this study, and from morphological and ITS sequence similarity, they should be regarded as the same species (Rees & Strid 2001). A small-statured collection occurring on fallen *Betula* branches, originally thought to represent *G. spectabilis* A.H. Smith var *junonius* Kühner & Romagnesi, did not differ from *G. junonius* (Fr.) P.D.Orton in its ITS 2 sequence (the only part of the region sequenced successfully). This result supports the synonymisation of the two species, *Gymnopilus spectabilis* and *G. junonius* by Orton (1960).

Gymnopilus sapineus sensu Høiland is a sister species to *Gymnopilus penetrans* and these form a sister group to *Gymnopilus hybridus*. However two other collections of *Gymnopilus sapineus* from Femsjö in southern Sweden where Fries did so much of his early collecting (Table 1), are very closely related to each other and form a separate, weakly supported clade with the red-coloured, scaly, Australian species *Gymnopilus moabus*. As a result, the identity of *G. sapineus* sensu Høiland (AJ 236079) could be *G. penetrans*. In a thorough investigative morphological and statistical examination of the three species in Norway, Høiland (1990) could perceive no outstanding difference between them. Detailed examination of the three Swedish collections included in an earlier study (Rees & Strid 2001) shows that cheilocystidia in *G. hybridus* are more lecythiform in shape with larger capitella than the other two species as indicated by Moser (1983). *Gymnopilus sapineus* is reported to be a less frequently encountered species and is generally fibrillose-scaly (Watling pers. comm.). In water soaked collections, scales tend to be obscured and identification is difficult. Conversely, glabrous species can become cracked and often scaly-looking in dry conditions.

The red-coloured species of *Gymnopilus* that are frequently encountered in Australia form a clade in which *G. norfolkensis* is a sister group to *G. mullaunius* and *G. luteofolius*, the latter from N. America. It has not been possible to obtain fresh material from Chile of the obviously related *G. purpuratus* (Cke. & Mass.) Singer with which to compare these collections. Rather surprisingly *G. moabus*, a small-statured Australian species with deep wine-red colours which intensify with age, is more closely related to *G.*

sapineus from the Northern Hemisphere. Both are recorded as having a scaly pileus surface. However the poor branch support for that relationship indicates that the placement of *G. moabus* remains equivocal. Only two red-coloured exotic species of *Gymnopilus*, *G. purpuratus* and *G. dilepis* have been reported from Northern Europe, although red-coloured species are endemic in North and Central America and geographically isolated countries in the Southern Hemisphere.

Gymnopilus crociphyllus and *Gymnopilus patriae* have similarly ornamented basidiospores but are quite distinct from each other microscopically with regard to spore size and cystidia shape (Rees & Ye 1999, Rees & Strid 2001). The most commonly occurring *Gymnopilus* species in Australia, *Gymnopilus allantopus*, which bears a strong resemblance to European *Gymnopilus hybridus* in the field and has similarly ornamented spores, is grouped with *G. crociphyllus* and *G. patriae.* Both *Gymnopilus crociphyllus* and *G. allantopus* have proven to be quite distinct from *G. penetrans* and *G. hybridus*, names commonly applied to them in Australia. *Gymnopilus allantopus* is synonymous with *G. austrosapineus* nom. prov. in Bougher & Syme (1998).

Two species, *Gymnopilus eucalyptorum* (Cleland)Singer, and the recently decribed *Gymnopilus tyallus* (Grgurinovic 1997) have a very similar DNA profile and are also similar morphologically. As it was not possible to extract DNA from the type material, a careful evaluation of more collections of the latter species need to be made before a definite conclusion can be reached. *Gymnopilus rimosus* from Western Australia seems to bear no resolvable relationship to other species at present.

Although all *Galerina* species (with the exception of *Gal. eucalyptorum* - now *Gymnopilus anomalus*) are distinct from the clade containing *Gymnopilus* species, Australian collections of *Galerina subcerina* and *G. tibiiformis* differ significantly in the two analyses and warrant further investigation.

Gymnopilus anomalus B.J.Rees nom. nov.
Galerina eucalyptorum E. Horak *Sydowia* 15: 65-80 (1987) non *Gymnopilus eucalyptorum* (Cleland) Singer.
Holotypus: AUSTRALIA: Western Australia: Quininup, Northcliff Forest Park, Snake Gully, 21.VI.1985, *E. Horak*, ZT 2708.

Galerina eucalyptorum was originally described by Horak (1987) as possessing *Gymnopilus*- like microcharacters, but was included in a group of *Galerina* species because it may have an excentric stipe. On the basis of the microscopic features, which have been more thoroughly investigated by Rees et al. (1999), and its DNA profile for the ITS region, *Galerina eucalyptorum* is recombined into *Gymnopilus*, but requires a new species name as *G. eucalyptorum* is already occupied. There are no detectable levels of styrylpyrone pigments in this species, but this character is no longer regarded as definitive for separating *Gymnopilus* from *Galerina* (Rees & Ye 1999).

Gymnopilus pyrrhum (Berk. & M.A.Curtis) B.J. Rees comb. nov.

Agaricus pyrrhus Berk. & M.A.Curtis, Journ. Linn. Soc. Bot. 10:291 (1868).
Crepidotus pyrrhus (Berk. & M.A.Curtis), Sacc. Syll. Fung. 5:879(1887).
C. laceratus Pat., Bull. Soc. Mycol. France 18: 172(1902).
C. substipitatus Murrill, Mycologia 6: 31 (1913).
Pyrrhoglossum pyrrhum (Berk. & M.A.Curtis) Singer, Mycologia 36:358 (1944)
Holotypus: CUBA: on dead wood, Wright 38(K).

Although *Pyrrhoglossum pyrrhum* was more or less centrally stipitate in young fruit bodies, it was obviously segregated on the basis of its pleurotoid habit at maturity. It shares many features with other *Gymnopilus* species viz. roughly ornamented, light gold-coloured spores with similar spore wall structure, pileus structure, capitate cheilo- and pleurocystidia, production of lemon-yellow pigment particularly in young fruit bodies, and a lignicolous habit. Although some spcies of *Phaeocollybia* possess cheilocystidia of a similar shape, they occur on soil in constant association with preferred host plant species, produce no styrylpyrone pigments, are often viscid to glutinous and are completely separate based on molecular data.

CONCLUSIONS

With the exception of *Gymnopilus junonius*, the molecular data confirm the unique identity of Australian species of *Gymnopilus*. These findings are in agreement not only with results for mycorrhizal genera in Australia such as *Amanita* where one might expect new species as host identity is significantly different (Wood 1997), but also in saprotrophic genera such as *Hygrocybe* (Young & Wood 1997), *Mycena* (Grgurinovic 2001) and *Galerina* (Wood 2001). Nevertheless some cosmopolitan species of these genera are present in Australia, and phylogenetic analyses confirm relationships between several groups of Northern and Southern Hemisphere species which support morphological findings (Rees & Strid 2001).

The presence of *Pyrrhoglossum pyrrhum* in close association with *Gymnopilus ferruginosus* in the *Gymnopilus* clade refutes the proposition that *Pyrrhoglossum* is most closely related to *Phaeocollybia* within the Cortinariaceae (Horak 1989). The presence of an excentric stipe is frequently encountered in a number of species of *Gymnopilus* (Rees & Ye 1999), and has led to the inclusion of several *Gymnopilus* species in *Pyrrhoglossum* by Singer, most of which have subsequently been restored to *Gymnopilus* (Horak 1989). The presence of stipe excentricity and absence of styrylpyrone pigments has also resulted in the inclusion of *Gymnopilus anomalus* in a group of excentric *Galerina* species as *Galerina eucalyptorum* (Horak 1987). The absence of styrylpyrone pigments from other species of *Gymnopilus* has already been established by Rees & Ye (1999).

The retention of *Gymnopilus penetrans* and *Gymnopilus hybridus* as separate species from *Gymnopilus sapineus* proposed by Orton (1993) is supported by molecular evidence. Further accurately described collections of these European species need to be sequenced before it can be decided if they form part of a very variable *Gymnopilus sapineus* complex. In the meanwhile species names should be preserved where morphological differences exist accompanied by supporting molecular evidence. Australian collections previously identified as these species have proved to be quite distinct microscopically and on molecular grounds (Rees & Strid 2001). This group of species illustrates the usefulness of molecular data in providing essential additional information in a genus in which species are hard to identify with certainty in the field, and in which microcharacters can often be surprisingly similar.

Overall, maximum parsimony and maximum likelihood analyses of the ITS sequence data have resulted in similar phylogenetic hypotheses for the taxa studied. Branch support was lowest for the basal branches in the maximum parsimony trees and higher at lower levels of classification. Thus while many groups of species are shown to be monophyletic, the relationships between these species within *Gymnopilus* remain unresolved. As sequence data become available from fresh material of other *Gymnopilus* species, it is expected that the phylogeny will become more resolved.

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Footnote:

Since this paper was submitted for review, additional ITS sequences for *Gymnopilus* species have been published (Moser et al. 2001; Peintner et al.

2001). In the former paper, a phylogenetic analysis of ITS sequences from eight separate *Gymnopilus* species has supported the retention of *Gymnopilus sapineus* and *G. penetrans* as separate species which accords with results described here. *Gymnopilus* species were used in the latter paper as outgroup taxa in a study of the multiple origins of sequestrate fungi related to *Cortinarius*.

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CREPIDOTUS MACEDONICUS, A NEW SPECIES FOR CENTRAL EUROPE

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ABSTRACT *Crepidotus macedonicus* is reported for the first time in Slovakia and Central Europe. The collections are described, illustrated, and compared with European orange gilled *Crepidotus* species.

KEY WORDS Basidiomycota, Crepidotaceae, *C. crocophyllus, C. ehrendorferi*, wood-inhabiting fungi, *Quercus*

INTRODUCTION

Pannonian oak-hornbeam, submediterranean xero-thermophilous oak wood and xero-thermophilous grasslands cover the Burda Mts. They are situated in the warmest area of Slovakia at the confluence of the Danube and the Ipeľ rivers (Michalko et al., 1987). A rather fleshy species of *Crepidotus* (Fr.) Staude with orange lamellae and velutinous, appressed pilose or villose, at first whitish, soon with shade of orange, later brown pileus surface has been collected by Ján Ripka from the Burda Mts. The only known Slovak *Crepidotus* species with orange lamellae is *Crepidotus crocophyllus* (Berk.) Sacc., which can be easily distinguished from the new specimen [Ripka's specimen in 2000 deposited in SLO] by having squamose, later fibrillose, chestnut, ferruginous or orange-rufous pileus surface coloured [all data are based on author's collections in 1997–2001 deposited in SLO]. Another European *Crepidotus* species with orange lamellae is *Crepidotus ehrendorferi* Hauskn. & Krisai. Its pileus surface is tomentose-farinose, at first greyish-orange, light orange, up to melon yellow when moist, and later light yellow, with pale, but distinct apricot shade when drying (cf. Hausknecht & Krisai, 1987).

I have found other significantly different anatomical characters, especially the shape of spores and the pileipellis structure, when studying *Crepidotus* specimen from the Burda Mts. The spores are lacrymoid (ellipsoid with suprahilar depression); the pileipellis is an intricate trichoderm, composed of 3–6 µm thick, cylindrical, straight, thin-walled, hyaline hyphae without differentiated terminal cells. The spores of *C. crocophyllus* are globose to subglobose; the pileipellis is a cutis, composed of 4.5–7.5 µm thick, cylindrical, thin-walled, hyaline hyphae. Squamules are formed by 6–22.5 µm thick, cylindrical, thin-walled, incrusted, hyaline to coloured, ascending hyphae. Their terminal cells are (7.5–)9–21.5(–31.5) × (36–)48–102(–112.5) µm, cylindrical, conical, fusiform or utriform, rounded or billed at apex, thick-walled, without incrustations, coloured [all data are based on author's collections in 1997–2001 deposited in SLO]. The spores of *C. ehrendorferi* are subglobose to globose; the pileipellis is a trichoderm composed of thin-walled, non-septate, erect, subregularly arranged, 6–9 µm thick hyphae (cf. Hausknecht & Krisai, 1987).

A comparative study of the recently collected *Crepidotus* specimen [Ripka's specimen in 2000 deposited in SLO] and the holotype specimen of *Crepidotus macedonicus* Pilát [Lindtner's & Pilát's specimen in 1937 deposited in PRM] has proved that both specimens are conspecific.

Current Slovak collections of *C. macedonicus* include specimens from the Burda Mts, the Podunajská nížina lowland, the Tríbeč Mts, the Pohronský Inovec Mts, the Poľana Mts, and the Štiavnické vrchy Mts.

MATERIAL AND METHODS

Collections of *Crepidotus macedonicus* Pilát from Slovakia consist of 46 fruit-bodies. The description is based on fresh material. The colour of the macroscopic characters, designated in alphanumeric form, follows Séguy (1936). Microscopic features are described from material mounted in 5% (aq.) KOH, Melzer's reagent, and Congo red (aq.). Microscopic measurements are given with an approximation of 0.75 µm. Out of 30 measurements (n = 30) of the microscopic features the size of the smallest (minimum), and the largest (maximum) elements are given. Strongly aberrant sizes are indicated in parentheses. Q is a quotient of length and width, av. Q is an average quotient. Terminology of microscopic features follows Vellinga's glossary (Vellinga, 1988). Herbarium specimens are deposited in SLO and BRA. The abbreviations of herbaria are cited in accordance with the Index Herbariorum (Holmgren et al., 1990). Bracketed inserts include explanatory notes.

DESCRIPTION

Crepidotus macedonicus Pilát (Fig. 1) has pleurotoid habitus without a stipe or a stipe visible only in very young fruit-bodies, 1–3 × 2–4 mm, white, tomentose. Pileus 15–75 × 15–55 mm, flabelliform, rounded flabelliform, irregularly circular, spathuliform or reniform, convex, plano-convex or applanate, laterally or dorsally attached to the substratum, slightly hygrophanous. Margin of the pileus at first revolute, soon inflexed, plane, undulate or sinuate, smooth. Pileus surface velutinous, appressed pilose or villose, whitish, soon with shade of orange (199), later brown (336), and at the point of pileus attachment tomentose, somewhat paler. Pileipellis an intricate trichoderm, composed of 3–6 µm thick, cylindrical, straight, thin walled, non-gelatinised, hyaline hyphae without differentiated terminal cells (Fig. 2). Tomentum at the point of attachment composed of 3–4.5 µm thick, cylindrical, thin-walled, hyaline hyphae. Pileus trama up to 4 mm thick, thicker below the point of attachment, whitish, composed of 6–12 µm thick, cylindrical, hyaline hyphae. Lamellae L=14–46, l=1–3, up to 7 mm wide, subventricose, ventricose, crowded, adnexed, at first whitish, soon orange (196) to brown-orange (186), later umber (176); edge fimbriate, whitish. Cheilocystidia 5.25–12 × 22.5–46.5 µm, clavate, cylindrical or utriform, in the upper part mostly branched, non-septate, thin-walled, hyaline (Fig. 2). Basidia 5.25–7.5 × 21–30.75 µm, 4-spored, clavate, thin-walled, hyaline (Fig. 2). Basidiospores

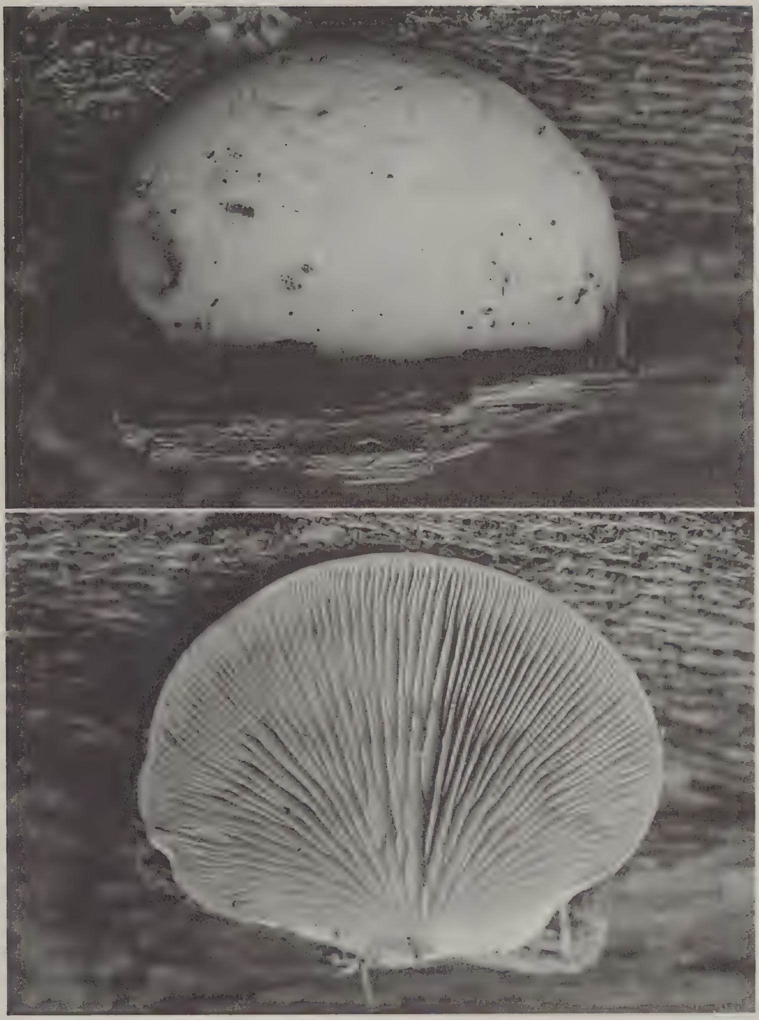

Fig. 1. *Crepidotus macedonicus*: above - pileus surface, below - hymenophor (magnification 2.25 ×).

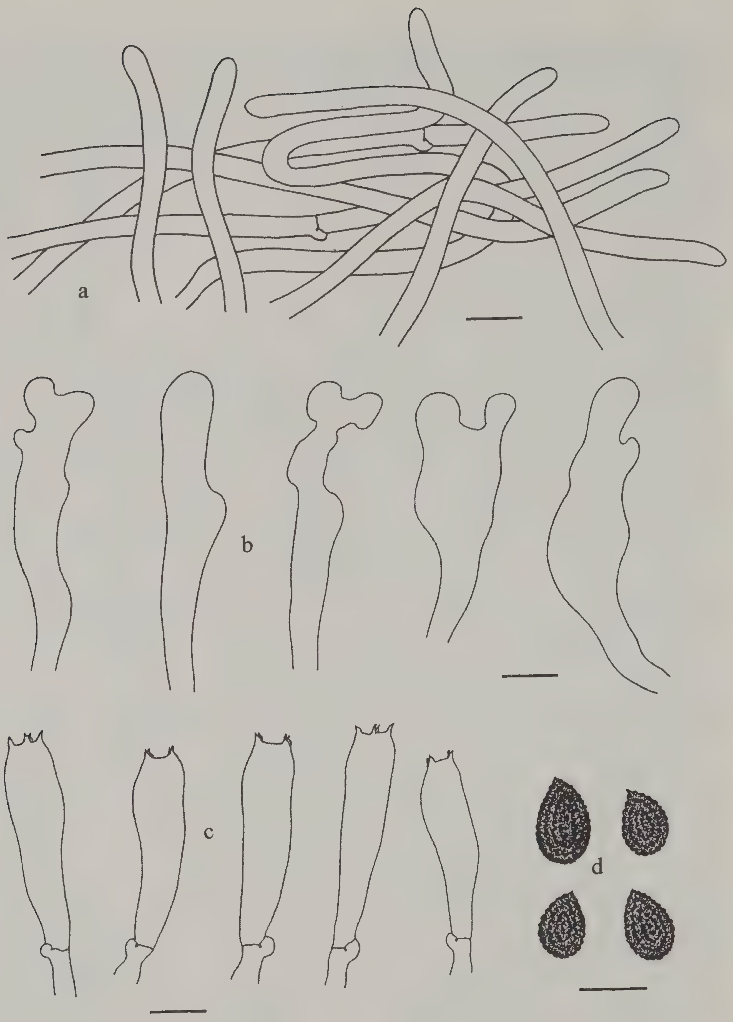

Fig. 2. *Crepidotus macedonicus*: a - pileipellis (scale bar = 10 µm), b - cheilocystidia (scale bar = 7.5 µm), c - basidia (scale bar = 7.5 µm), d - basidospores (scale bar = 7.5 µm).

3.75–5.25 × 4.5–7.5 µm, Q=1.2–1.67, av. Q=1.45, lacrymoid (ellipsoid with suprahilar depression), verruculose, yellowish (Fig. 2). Spores print fulvous (192). Clamp connections present.

RESULTS AND DISCUSSION

Crepidotus macedonicus was described by Pilát (1948a, 1948b). The taxon was validly published later when he provided a Latin diagnosis (Pilát, 1949). Pilát (1948a, 1948b) noted that *C. macedonicus* is macroscopically similar to *Crepidotus panuoides* Fr. [= *Paxillus panuoides* (Fr.) Fr.]. He described the colour of the lamellae as at first yellow-crocus, later pale cinnamon. Pilát (1948a, 1948b, 1949) pointed out that his description of *C. macedonicus* was based on dried material (Tab. 1) and the colour of the lamellae described as argillaceous-fuscous and fuscous in a herbarium specimen. Pilát's holotype of *C. macedonicus* was studied by several mycologists: in 1964 by L. R. Hesler, who also provided the holotype's description (Tab. 1), in 1977 by E. Horak, and in 1990 by B. Senn-Irlet, who provided a SEM photograph of holotype's spores. Also in 1998 by V. M. Bandala. The holotype of *C. macedonicus* is in poor condition but the characters of spores have revealed a rather typical species of the genus *Crepidotus*.

Horak (1964) published the second known record of *C. macedonicus*. Horak's description of the collection from Yugoslavia was based on fresh material (Tab. 1).

Senn-Irlet (1992) published a description of *C. macedonicus* based on unpublished notes of L. R. Hesler and her own observations of the type collection (Tab. 1). Later Senn-Irlet (1995) presented a macroscopic description compiled by Horak (1964).

C. macedonicus was reported also from France (Hairaud, 1999; Chapon et al., 2001). Hairaud (1999) and Chapon et al. (2001) presented data from fresh material (Tab. 1).

The table 1 compares descriptions of diacritical characters, such as colour of the lamellae surface, pileipellis, cheilocystidia and spores, of *C. macedonicus* from Macedonia, Yugoslavia, France and Slovakia. Hesler (1964) and Senn-Irlet (1992) did not mention colour of the lamellae surface, that is at first whitish, soon with shade of orange, later brown, persisting in herbarium specimens too, because they studied only the holotype. From the other authors investigating fresh material, only Pilát (1949) did not mention the white colour of the lamellae, that is visible only in very young fruit-bodies. Pilát (1949) and Horak (1964) did not even mention the orange colour of the lamellae distinguishing the species. Senn-Irlet (1995) did not believe the reliability of characters of the pileipellis for taxonomic purposes due to frequent presence of intermediate forms. The shape of cheilocystidia is variable: cylindrical, clavate, utriform, lecythiform, ventricose etc. Pilát (1949) and Horak (1964) noted absence of cheilocystidia. Hesler (1964) mentioned pleurocystidia although these have never been observed in European *Crepidotus* species. The authors reported more-or-less the same size of spores, and although they described spore shape differently, their illustrations are very similar.

Table 1. Description of diacritical characters of *Crepidotus macedonicus*

	Pilát (1949)	Hesler (1964)	Horak (1964)	Senn-Irlet (1992)	Hairaud (1999)	Chapon et al. (2001)	Slovak collections
Colour of the lamellae surface	argillaceo-fuscae, in speciminibus exsiccatis obscure fuscae	[non-refered]	jung weiß, alt auffällig ockerbraun (auch am Exsikkat)	[non-refered]	blanches puis envahies de roux orangé	blanches sans reflet rose, puis ocre, enfin orangé vif à maturité	at first whitish, soon orange to brown-orange, later umber
Pileipellis	cutis haud evoluta est. Fines hypharum in pilei superficie obtusae et ibi 5–8 µ crassae	cuticle of repent hyphae, bearing a turf of colorless to pale fuscous, narrow, (3–5 µ) hyphae, usually in bundles or strands	aus parallel-radiären hyalinen Hyphen, glatt, nicht pigmentinkrustiert, zylindrisch, septiert mit Schnallen, 3–5 µ Durchmesser, nicht gelatinös	a cutis of repent hyphae, bearing tufts of more or less erect colourless to pale fuscous, narrow, 3–5 µm wide hyphae	d'hyphes cylindriques larges de 5 µm, en moyenne	en cutis portant de nombreuses hyphes redressées en poils faisant transition avec un trichoderme. Hyphes à boucles nombreuses × 3–5 µm	a intricate trichoderm, made up of 3–6 µm thick, cylindrical, straight, thin-walled, non-gelatinised, hyaline hyphae without differentiated terminal cells
Cheilocystidia	nulla	6–15 × 32–50 µ, clustered, conspicuous, variable: nine-pin-shaped-capitate, cylindric, clavate, ventricose, often irregularly forked-knobbed	fehlen	5–15 × 32–50 µm, conspicuous, variable, lecythiform, cylindrical, clavate or ventricose, capitate or not, often irregularly forked and knobbed	6–10 × 25–50 µm, cylindriques, clavées, utriformes, diverticulées	10.7–15 × 31–61.5 µm, claviformes, parfois subcylindriques ou un peu utriformes, souvent plus ou moins fléxueuses, avec des excroissances digitées, irrégulières	5.25–12 × 22.5–46.5 µm, clavate, cylindrical or utriform, in the upper part mostly branched, non-septate, thin-walled, hyaline
Spores	4.6–5 × 5.5–6.2 µm, globoso- vel ovato-pyriformes, argillaceo-luteo-fuscae, distincte verrucosae, apiculo distincto munitae	4–5 × (5–)5.5–7 µ, ovoid to ellipsoid, at times subglobose, strongly punctate-echinulate, brown	4.4–4.8 × 5.2–6.4 µ, oval bis tropfig, schwache Hilardepression und mit verlängertem Apiculus, fein punktiert, isoliert, warzig, s. m. bräunlich	4–6 × 5–7.5 µm, ellipsoid, ovoid, sometimes subglobose, punctate in frontal view, distinctly warty in optical section; walls pale brownish	4.2–5.5 × 6–7.5 µm, en gouttes d'eau, non symétriques, verruqueuses	4–5.5 × 6–7.1 µm, verruqueuses, larmiformes, assymétriques avec une légère dépression supra-apiculaire observées de profil, oblongues vues de face, brun-jaunâtre	3.75–5.25 × 4.5–7.5 µm, lacrymoid (ellipsoid with suprahilar depression), verruculose, yellowish

ECOLOGY

According to available European records *Crepidotus macedonicus* Pilát is a rare agaric macrofungus [listed in the Red List of Slovak fungi (Lizoň, 2001)] known as a saprophyte of woody substrates, i. e. trunks and branches of deciduous trees. *C. macedonicus* was recorded in Macedonia, Yugoslavia and France only on *Fagus sylvatica* (Pilát, 1949; Horak, 1964; Hairaud, 1999; Chapon et al., 2001), in Slovakia on *Quercus* sp., *Q. cerris* and *Q. rubra*.

MATERIAL STUDIED

Macedonia: the Šar planina Mts, near Crni Kamen, in Fagetis, cca 1100 m s. a. l., on *Fagus sylvatica*, August 1937, leg. A. Pilát & V. Lindtner (PRM, holotype). **Slovakia, Burda Mts:** the Kováčovské kopce hills, near Štúrovo town, 400 m s. a. l., on fallen branch of *Quercus* sp., 14 Aug. 1970, leg. J. Kuthan [as *Crepidotus caspari* Velen.] (BRA). • National Nature Reserve Kováčovské kopce - juh, cca 2 km NE from Kamenica nad Hronom village, thermophilic mixed oak woods submediterranean (*Quercus cerris*, *Acer campestre*, *Crataegus* sp., *Cornus mas*), 270 m s. a. l., on wood of fallen, rotten [= structure of wood and bark is almost unrecognizable] trunk of *Quercus cerris*, 21 Aug. 2000, leg. J. Ripka (SLO). Ibidem, φ = 47°49'58", λ = 18°44'55" (WGS 84), 7 Aug. 2001, leg. S. Jančovičová (SLO). **Podunajská nížina lowland:** Šenkvice village, Šenkvický háj grove, oak woods (*Quercus rubra*) with undergrowth of *Rubus* sp., cca 200 m s. a. l., on bark of fallen, decaying [= structure of wood and bark is partly demaged] branch of *Quercus rubra*, 28 July 2001, leg. J. Červenka (SLO). **Tríbeč Mts:** cca 4 km SW from Skýcov village or cca 2 km E from Topoľčianska zubria zvernica preserve, cca 380 m s. a. l., on wood of *Quercus* sp., 10 Sept. 1981, leg. L. Hagara [as *Crepidotus luteolus* (Lambotte) Sacc.] (BRA). **Pohronský Inovec Mts:** Topoľnica valley, near Topoľčianky village, 350 m s. a. l., on decaying branch of deciduous tree, 10 Sept. 1981, leg. J. Kuthan, [as *Crepidotus* sp.] (BRA). **Poľana Mts:** near Dúbravica village, Banská Bystrica district, cca 650 m s. a. l., on decaying trunk of *Quercus* sp., 9 June 1984, leg. J. Kuthan [as *Crepidotus applanatus* (Pers.) P. Kumm.] (BRA). **Štiavnické vrchy Mts:** Ladzany village, near Hontianske Nemce village, 250 m s. a. l., on branch of deciduous tree, 18 Sept. 1979, leg. J. Kuthan [as *Crepidotus mollis* (Bull.) P. Kumm.] (BRA). • The Čierne Blato hill, near Baďan village, cca 550 m s. a. l., on fallen twig of *Quercus* sp., 18 Sept. 1984, leg. J. Kuthan [as *Crepidotus applanatus* (Pers.) P. Kumm.] (BRA). • The Háj hill, 3 km NW from Ladzany village, Zvolen district, cca 380 m s. a. l., on branch of *Quercus* sp., 20 Sept. 1984, leg. L. Hagara [as *Crepidotus mollis* (Bull.) P. Kumm.] (BRA). • Ladzany village, the Veľký Gregor hill, 420 m s. a. l., on fallen branch of *Quercus* sp., 14 Sept. 2001, leg. L. Hagara [as *Crepidotus* sp.] (herb. of L. Hagara). • Ladzany village, cca 250 m NE from the Veľký Gregor hill - φ = 48°17'53", λ = 18°51'06" (WGS 84), mixed oak wood (*Quercus cerris*, *Q. rubra*, *Sorbus torminosus*, *Tilia* sp.), cca 420 m s. a. l., on bark of fallen, rotten branch of *Quercus* sp., 7 Oct. 2001, leg. I. Kautmanová (SLO). Ibidem, on bark of fallen, rotten branch of *Quercus cerris*, leg. J. Ripka. Ibidem, on wood of fallen, rotten branch of *Quercus* sp., leg. S. Ripková. Ibidem, on bark of fallen, decaying branch of *Quercus cerris*, leg. S. Ripková & J. Ripka.

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FIRST RECORD OF *ENTOLOMA PLEBEIOIDES* IN ITALY

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ABSTRACT. *Entoloma plebeioides*, previously recorded only for the Netherlands and Austria, was collected for the first time in Italy. The new locality is located in a green-belt of the town of Palermo (Sicily, South Italy).

KEY WORDS: Important Fungus Areas (IFA's), rare *Entoloma* species, Sicily.

INTRODUCTION

In the framework of a research program aimed at the assessment of fungal biodiversity in Sicily (South Italy) and for the delimitation of Important Fungus Areas (IFA's), periodical observations in different ecosystems were carried out.

The Favorita Park, a green-belt located in the town of Palermo, is one of the IFA's of Sicily. The vegetation of the Favorita Park was previously investigated by Buffa & al. (1986) while mycoflorisitc studies were carried out by Inzenga (1865-1869) and Venturella & al. (2001).

In the course of the years the original plant cover was largely modified by anthropic pressure, for this reason projects of restoration was proposed by Buffa & al. (1993). Subsequently many exotic plants belonging to different genera such as *Eucalyptus* L'Hér., *Pinus* L., *Cedrus* Trew. and *Cupressus* L. were progressively replaced by native species i. e. *Quercus ilex* L. and *Quercus pubescens* Willd. Owing to the young age of these plants the percentage of plant cover is actually very low (less than 30 %) and the glades of the oak plantations are mainly characterized by the presence of herbaceous plants such as *Urtica membranacea* Poiret, *Oxalis pes-caprae* L., *Lolium perenne* L. and *Oryzopsis miliacea* (L.) Asch. et Schweinf.

In this type of vegetation, on December 2001, during a field investigation, a rare *Entoloma* species was collected.

MATERIALS AND METHODS

The macroscopic and microscopic features of fresh basidiomata were observed using the identification key for *Entoloma* of Noordeloos (1992) and a Leica DMLS microscope.

The dried material was preserved in a paper box and subsequently rehydrated with KOH (5 %) for more detailed observations.

The herbarium specimens are kept in the Herbarium Mediterraneum of Palermo (PAL) and Nationaal Herbarium Nederland (L)

DISCUSSION

Entoloma plebeioides (Schulz.) Noordel. is a rare *Entoloma* species that, according to Noordeloos (1992), belonging to subg. *Inocephalus*, sect. *Erophila*.

The habitus of *E. plebeioides* is similar to *Entoloma* species belonging to the so-named "*rhodopolium* group" except for the fibrillose-squamulose pileus. This autumnal *Entoloma* species is morphologically separated from the vernal *E. plebejum* (Kalchbr.) Noordel. by the dark-brown coloured and fibrillose-squamulose cap and different size and shape of the spores.

E. plebeioides was previously recorded from the Netherlands by Noordeloos (1987) in poorly manured extensively grazed grassland in old, decalcified coastal dunes and in humus-rich *Alnus* and *Fraxinus* forest.

Afterwards Noordeloos & Hansknecht (1989) reported a description and illustrations of *E. plebeioides* from Austria.

In Sicily *Entoloma plebeioides* was collected on December 2001 in the Favorita Park, in a glade near a conifer plantations of *Pinus halepensis* Miller, *Cupressus sempervirens* L., *C. macrocarpa* Hartweg and *Cedrus deodara* (D. Don) G. Don.

The soil is a typical Mediterranean Red Soil on limestone corresponding to Lithic rhodoxeralfs in the USDA Soil Taxonomy (Soil Survey Staff, 1975). The soil is characterized by a prevalence of sandy particles and a neutral reaction (pH 6.8-7.1). The whole area is strongly influenced by anthropic pressure.

The climatic trend of the year 2001, in Palermo, has been characterized by a long drought period from June to the middle of November. Afterwards temperatures drastically decreased and an unusual number of rainy days was registered.

Such unexpected climatic variation, very unusual for a region like Sicily characterized by a thermo-mediterranean climate, could probably have brought about the appearance of *E. plebeioides*, a species never collected before.

The finding of *E. plebeioides*, hitherto considered restricted to central and northern Europe, extends southward the distribution area of this rare species.

ACKNOWLEDGEMENTS

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A NEW SPECIES OF THE GENUS AMAZONIA FROM CHINA

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ABSTRACT

Amazonia rogergoosii, parasitic on *Strophanthus divaricatus*, is described and illustrated as a new species.

Key words : *Strophanthus, Amazonia,* China.

The genus *Amazonia* was established by Theissen in 1913 with the type species, *A. psychotriae* (P.Henn.) Theiss. based on *Meliola asterinoides* Wint. var. *psychotriae* P. Henn. This genus differs from other genera of Meliolaceae in having flattened-globose perithecia and devoid of mycelial and perithecial appendages and setae (Hansford, 1961, 1963; Hu *et al.* 1999). This genus constitutes about 46 species (Hawksworth *et al.* 1995; Hosagoudar *et al.*1997).

Amazonia rogergoosii sp. nov. (Fig. 1)

Coloniae amphigenae, nigrescentes, densae, dispersae, subcrustosae vel velutinae, ad 4 mm diam., raro confluentes. Hyphae rectae vel leniter undulatae, alternatim vel unilateralis acuteque ramosae, dense reticulatae, cellulae 8-15 x 5-7 µm. Appressoria alternata, unilateralia, dense posita, antrorsa, recta vel leniter curvula, 12-15 µm longa; cellulae basilares cylindraceae vel cuneatae, 2-5 µm longae; cellulae apicales ovatae vel globosae, integrae, 8-10 x 6-9 µm. Phialides paucae, appressoriis intermixtae, alternatae vel oppositae, ampulliformes, 13-23 x 5-7 µm. Perithecia laxe aggregata, nigra, dippresso-globosa, cellulae radiatae, ad 320 µm diam.; ascosporae brunneae, oblongae, obtusae, 4-septatae, constrictae, 32-38 x 12-17 µm.

Colonies amphigenous, black, dense, scattered, subcrustose, velvety, up to 4 mm in diameter, rarely confluent. Hyphae straight to slightly undulate, branching alternate to unilateral

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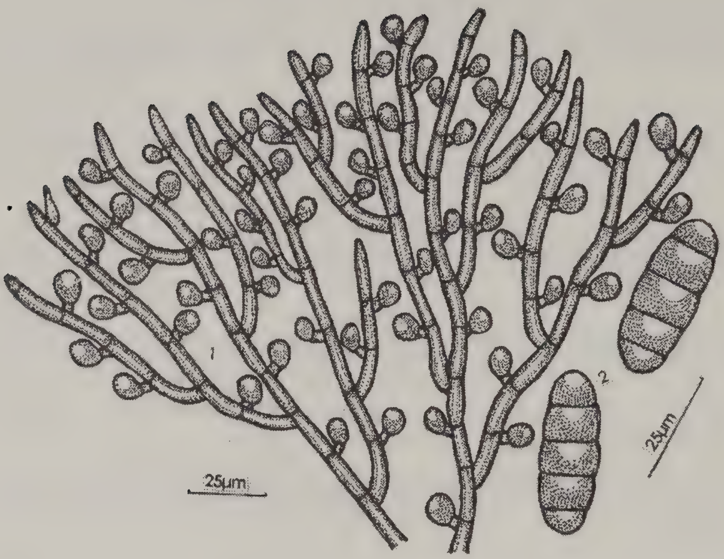

Fig. 1 *Amazonia rogergoosii* sp. nov.
1. Hyphae with appressoria and phialides; 2. Ascospores.

at acute angles, closely reticulate, cells 8-15 x 5-7 μm. Appressoria alternate, unilateral, crowded, antrorse, straight to slightly curved, 12-15 μm long; stalk cells cylindrical to cuneate, 2-5 μm long; head cells ovate to globose, entire, 8-10 x 6-9 μm. Phialides few, mixed with appressoria, alternate to opposite, ampulliform, 13-23 x 5-7 μm. Perithecia loosely grouped at the centre, black, flattened-globose with radiating cells, up to 320 μm in diameter; ascospores brown, oblong, obtuse, 4-septate, constricted at the septa, 32-38 x 12-17 μm.

Holotype: On leaves of *Strophanthus divaricatus* (Lour.) Hook. & Arn. (Apocynaceae), Zengcheng, Guangdong Province, China, Sept. 9, 1987, Hu Hai HMIGD 30789.

Amazonia alyxiae Hansf. was the only known species of the genus *Amazonia* on *Alyxia olivaeformis* from Hawaii (Hansford, 1961). The new species differs from it in having shorter appressoria and smaller ascospores.

This species is named in honour of Prof. Roger D. Goos.

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NOTES ON SEVERAL BOLETI FROM YUNNAN, CHINA[1]

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Abstract: Revisions and notes on several boleti published or recorded from Yunnan are presented. One new combination is ***Boletellus puniceus***. *Boletus megasporus* is identical with *B. puniceus*. *Boletus tomentulosus* and *Boletus umbriniporus* are synonyms of *Boletus brunneissimus*. *Boletus crocipodius sensu* W.F. Chiu is *Leccinum extremiorientale*. Notes are also made on *Heimiella retispora* based on several Yunnan specimens.

Key words: Types, *Boletellus puniceus*, Synonym

In the last century many new or interesting species of boleti were reported from Yunnan, China (Chiu, 1948, 1957; Keissler & Lohwag, 1937; Teng, 1963: 545; Ying, 1986; Ying & Ma, 1995; Zang, 1980, 1983, 1991a, 1992; Zang *et al.*, 1993). Some of them are endemic in China, East Asia or Southeast Asia. A recent re-examination of several types and additional collections deposited in HKAS, HMAS and TNS provided some note-worthy information on several taxa.

Color notations are from A. Kornerup & J. H. Wanscher "Methuen Handbook of Color" 3rd Ed., London (1978). For notations and abbreviations of data for spores see Yang (2000).

1. *Boletus brunneissimus* W.F. Chiu, Mycologia **40(2):** 228 (1948).
=*Boletus umbriniporus* Hongo, Journ. Jap. Bot. **44:** 235, Fig. 2. 4-7 (1969).
=*Boletus tomentulosus* M. Zang, W.P. Liu et M.R. Hu, Acta Bot. Yunnanica **13(2):** 150, Fig.1. 4-6 (1991).

Pileus 4-10 cm in diam, convex, wholly velvety to sub-velvety, more or less viscid when wet, drying often cracked, light brown (5D7), brown (5E8) to dark brown when fresh, brown (6E6) to dark brown (6F5-6F6) in dry specimens. Stipe 3-7 cm long, 0.5-2 cm thick, cylindric, equal or swollen at base, solid, not reticulate, minutely scurfy with numerous dark brown dots, apex yellow to yellowish-brown (5D6), middle and base dark

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brown (6F6), base prominently strigose with yellowish brown hairs. Tubes 5-6 mm long, almost free, yellowish; pores minute, deep yellowish brown to dark brown (6F6). Flesh 5-15 mm thick, yellow, flesh inside stipe yellowish brown, upper portion cyanescent, base slightly or not. All parts of the basidiome deeply and quickly cyanescent when bruised. Taste mild. Odor not distinctive.

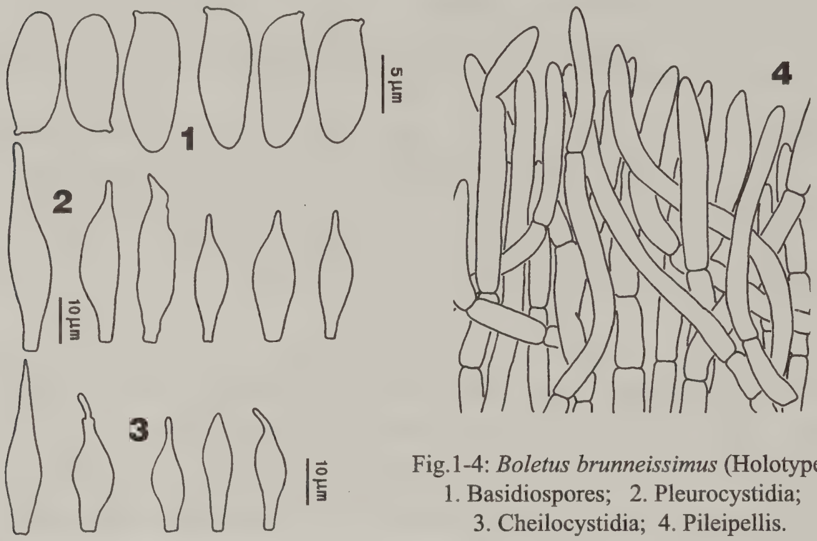

Fig.1-4: *Boletus brunneissimus* (Holotype).
1. Basidiospores; 2. Pleurocystidia;
3. Cheilocystidia; 4. Pileipellis.

Spores [201/5/5] (8.0-)9.0-12.0(-14.0) × (3.7-)4.0-5.0(-5.8) µm [Q = (1.82-)2.20-2.86(-3.48), **Q** = 2.47 ± 0.20], smooth, boletoid, yellowish brown. Pleurocystidia 23.0-60.0 × 6.0-12.5 µm, abundant, fusiform, apex often sharply pointed, almost hyaline or with dense yellowish-brown contents. Cheilocystidia 25.0-55.0 × 6.0-10.5 µm, abundant, similar to pleurocystidia. Pileipellis a compact pile, 80-100 µm thick, composed of erect hyphae, 4-7 µm wide, with yellowish-brown contents, terminal cells with obtuse tips. Surface of the stipe covered with a compact hymenium of clavate sterile basidia and fusiform thin-walled cystidia, Hairs at stipe base composed of fasciculate hyphae, 2.5-5 µm wide, thin-walled to slightly thick-walled, yellowish brown, some branched, septate, terminal cells rounded to slightly attenuate. Clamps absent on all septa.

Specimens Examined: Kunming market, 25. VI. 1931, W. F. Chiu 7864 (HMAS 07249) (**Holotype!**); Songming market, 13. IX. 1997, X. H. Wang 98 (HKAS 31664); Kunming market, 26. VIII. 1997, X. H. Wang 30 (HKAS 31821); Songming market, 17. VI. 1998, X. H. Wang 250 (HKAS 32693); Kunming market, 23. VI. 1998, X. H. Wang 273 (HKAS 32698).

Hab.: Under *Pinus* or in mixed forests.

Note: Some dark staining on the pores indicating that the hymenophore was cyanescent when bruised, and the dense hairs at the stipe base were observed on the holotype. Both characters were also found on all of the other collections cited above. They are the most typical and distinctive characters of this fungus. However, because they were not mentioned by Chiu (1948, 1957: 136-141), they had been overlooked before. Due to the yellowish and cyanescent tubes and the brownish pores, *B. brunneissimus* belongs to sect. *Boletus* subsect. *Luridi* (Fr.) A. H. Sm. et Thiers.

In subsect. *Luridi* there are several species similar to this species. The North American *B. vermiculosus* Peck can be distinguished from *B. brunneissimus* in the pileus and pores with a red tone, not scurfy stipe and longer spores (11-15 × 4–4.5(-6) μm) (see Smith & Thiers, 1971: 333-336). Though the pileus and pores of *B. vermiculosoides* A. H. Sm. et Thiers lack a reddish tinge, its stipe is not punctate, pileipellis not trichodermium and spores much narrower (9-12 × 3–3.5 μm) (see Smith & Thiers, 1971: 337-338).

In Southeast Asia and adjacent regions, *B. kumaeus* R. Heim has several characters in common with *B. brunneissimus*, but it differs by the reddish tinge on the pileus, stipe and pores (see Heim, 1963). *Boletus kumaeus* var. *rubricollum* Corner is more similar to *B. brunneissimus* (Corner, 1972: 112-113), however, stipe apex of *B. brunneissimus* is never red and the terminal cells of the pileipellis are not so acute as shown in Corner's illustrations (see Corner, 1972: 112-113).

The three Japanese species with brownish pores, *B. fuscopunctatus* Hongo et Nagas., *B. obscureumbrinus* Hongo and *B. umbriniporus* Hongo are closer to this fungus. The basidiomes of the former two, however, are much stouter (see Hongo, 1968, 1976b, 1978) and, in particular, the stipe base of *B. fuscopunctatus* is not strigose (Hongo, 1976b, 1978) and the stipe of *B. obscureumbrinus* is not punctate (Hongo, 1968). *Boletus umbriniporus,* the species regarded to be close to *B. erythropus* (Fr.) Fr. and *B. nigro-violaceus* R. Heim (Hongo, 1969, 1978), actually fits *B. brunneissimus* better. Re-examination of both holotypes HMAS 07249 (*B. brunneissimus*) and TNS-F-174783 (*B. umbriniporus*) proved the two taxa are identical in every aspect.

Boletus tomentulosus M. Zang, W.P. Liu et M.R. Hu, a species reported from Fujian, China, differs from *B. brunneissimus* only by the larger spores and the lack of pleuro- and cheilocystidia (see Zang *et al.*, 1991). However re-examination of the holotype (HKAS 18718) showed that the spores are [40/1/1] (9.7-) 10.0-12.5 (-13.0) × 4.0-5.0 μm [Q = (1.82-) 2.20-2.86 (-3.48), **Q** = 2.47 ± 0.20], almost the same as those of *B. brunneissimus* and the cystidia are abundant in the hymenium (see Fig. 5-6). We noticed that the cystidia of the two holotypes are somewhat different in dimension and color. The specimens collected at the same locality and sharing the same characters as those of the holotype of *B. brunneissimus* bear cystidia with variable morphology. We suspect that the cystidia of *B.*

brunneissimus might be variable because of different environments and development stages of the basidiomes. Because there are no fundamental differences between *B. brunneissimus* and *B. tomentulosus*, we regard the latter as a synonym of the former.

This mushroom is sold as an edible fungus in large quantity on the markets in Central Yunnan. Its local name "Cat Eye Mushroom" and "Black Goat Liver" suggest the color of the basidiomes.

Only reported in China and Japan up to now, it might be a typical element of East Asia.

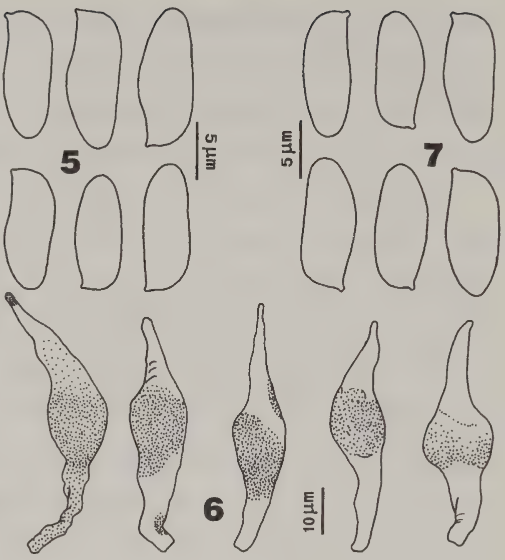

Fig. 5-6: *Boletus tomentulosus* (Holotype).
5. Basidiospores; 6. Pleurocystidia.
Fig. 7: *B. umbriniporus* (Holotype).
7. Basidiospores.

2. *Boletellus puniceus* (W.F. Chiu) X.H. Wang et P.G. Liu, comb. nov.

≡*Boletus puniceus* W.F. Chiu, Mycologia **40(2):** 217 (1948).

≡*Xerocomus puniceus* (W.F. Chiu) F.L. Tai, Syll. Fung. Sin. 815 (1979).

=*Boletus megasporus* [as "*magasporus*"] M. Zang, Acta Micro. Sin. **20(1):** 30, Fig.1.3-4 (1981).

Pileus 3.5-8 cm in diam, hemispheric to convex, subvelvety to subtomentose all over, margin minutely squamulose, carmine to light rose-reddish. Stipe 6-11 cm long, 0.8-2 cm thick, cylindric, equal or slightly attenuate upwards, almost glabrous to minutely fibrillose, concolorous with pileus. Tubes 1-1.7 cm long, sinuate, bright yellow, not cyanescent; pores 1-2.5 mm wide, angular, bright yellow. Flesh whitish, not cyanescent. Taste bitter. Odor not distinctive.

Spores [266/8/7] (14.0-)15.0-18.5(-20.0) × 6.0-8.0(-9.0) µm [Q = (1.90-)2.07-2.69(-2.92), **Q** = 2.37 ± 0.19], broadly fusoid, ochraceous brown, with inconspicuous longitudinal striations. Basidia 37.5-50.0 × 10.0-17.5 µm, clavate. Pleuro- and cheilocystidia 50-70 × 10-18 µm, scattered, conspicuous, ventricose, apex subcapitate, thin-walled, often with yellowish-brown content. Pileipellis composed of somewhat inflated hyphae, as a pile, end cells about 10-15 µm wide. Surface of the stipe composed of longitudinal parallel hyphae, 4.5-9 µm wide. Clamps absent.

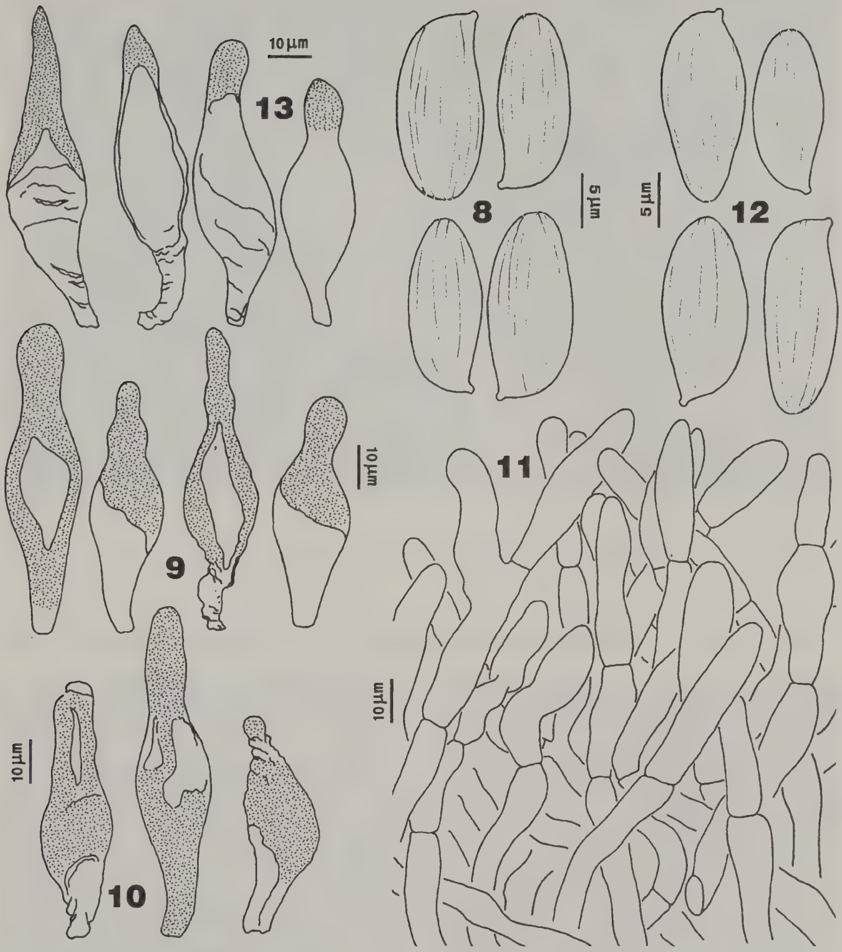

Fig. 8-11: *Boletellus puniceus* (Holotype).
8. Basidiospores; 9. Cheilocystidia; 10. Pleurocystidia; 11. Pileipellis.
Fig. 12-13: *Boletus megasporus* (Holotype).
12. Basidiospores; 13. Cystidia.

Specimens Examined: Yunnan: Kunming, Miaogaosi ("Miaokaotze"), H. R. Wang & K. S. Hu, 30. IX. 1942, HMAS 3852 (= Tsinghua 7852) (**Holotype!**); Gaoligongshan, Tushaling, 11. IX. 1978, Zang 3911 (HKAS 3911); Gaoligongshan, Bolajing, 2200 m, 7. VII. 1978, Zang 3963 (HKAS 3963) (Holotype of *Boletus megasporus*); Gaoligongshan, Bola, 9. VII. 1978, Zang 4038 (HKAS 4038); Gaoligongshan, Pila, 2400 m, 12. VII. 1978, Zang 4060 (HKAS 4060); Songming, Aziying, 17. VI. 1998, X. H. Wang 242 (HKAS 31905); Jingdong, Xujiaba, 7. VII. 2000, Q. B. Wang 652 (HKAS 37152). **Tibet:** Xiachayu, 1800-2000 m, 3. IX. 1976, Zang 930 (HKAS 28932).

Hab.: On soil in mixed forest under *Camellia, Castanopsis, Lithocarpus, Pinus yunnanensis, Taiwania flousiana*, bamboo.

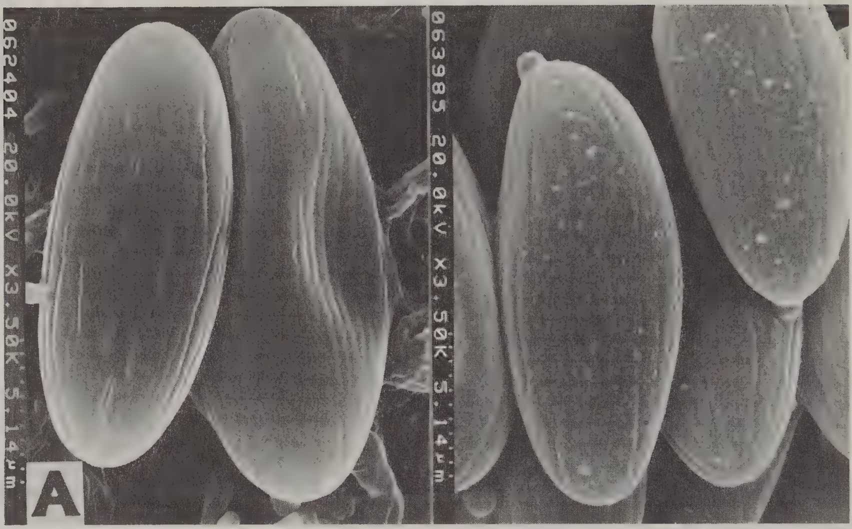

Plate. 1 Scanning Electron Micrographs of Spores
A: *Boletellus puniceus* (HKAS 38218) B: *Boletus megasporus* (Holotype)

Note: The holotype of *Boletus puniceus* W.F. Chiu was transferred from the Plant Pathology Herbarium of Tsinghua University to HMAS. No. 7825 was assigned as the type when the species was published. In HMAS, however, the type is HMAS 3852 (Tsinghua 7852). 7825 is clearly a typographic error.

The species was transferred into *Xerocomus* by Tai (1979) for the tomentose pileus. Without studying the type of *B. puniceus*, Corner (1972: 101) questioned the presence of smooth spores and suspected that *B. puniceus* is the same as *B. obscurecoccineus* (Höhn.) Singer. Chiu (1948, 1957: 80-81) described and illustrated its spores as smooth. Re-examination of the holotype showed that it is a *Boletellus* with very faintly longitudinally striated spores. The striations are rather clear under SEM (see Pl. 1). The large and longitudinally ornamented spores combined with the broad pores of this species indicate placement in the genus *Boletellus*. Thus the new combination is proposed here.

With the carmine basidiomes and large spores, the Yunnan species *B. megasporus* M. Zang was considered to be close to *B. puniceus* but differs from the latter by its smooth stipe, bitter flesh and larger spores (Zang, 1980). The spores of both holotypes were re-measured: *B. megasporus* (HKAS 3963): [72/2/1] (14.5-)15.0-19.0(-20.0) × (6.0-)6.5-8.0(-9.0) µm [Q = (2.00-)2.12-2.69(-2.77), **Q** = 2.38 ± 0.17]; *B. puniceus* (HMAS 3852): [74/1/1] 15.0-18.0(-19.3) × (6.3-)6.7-8.0(-9.0) µm [Q = (1.90-)2.05-2.54 (-2.64), **Q** = 2.30 ± 0.16]. The spores of both holotypes are faintly longitudinally striated. Both stipes are composed of longitudinally arranged parallel hyphae. The collections most like *B. puniceus* recently obtained from the type locality and the adjacent areas have bitter flesh. No essential difference was found.

Singer (1945) reported that the type of *B. obscure-coccineus* bears large spores with distinct ridges; those of *B. puniceus* are only faintly striated to even smooth.

3. *Heimiella retispora* (Pat. et Baker) Boedijn, Sydowia **5:** 216 (1951).

≡*Boletus retisporus* Pat. et Baker, Journ. Straits Branch. R. Asiatic Soc. 87. 72 (1918).

Pileus 3-7 cm in diam, hemispherical then convex, subtomentose, slightly greasy when wet, red to deep red, darker at center. Stipe 6-14 cm long, 0.6-1.2 cm thick at apex, 1.0-3.0 cm thick at the base, attenuate towards the apex, the apex clear yellow, middle and base dark-red, over whole length coarsely reticulate, meshes on the upper and middle portion bright yellowish, at base reddish, mycelium at base whitish or with faint ochraceous tinge. Tubes up to 1.5 cm long, deeply depressed, yellow; pores small to medium-size, yellowish near pileus margin, often red and with orange tinge towards the center, unchanging or faintly cyanescent. Flesh 4-6 mm thick halfway to the margin, yellow, red beneath cutis, unchanging or faintly cyanescent only. Taste mild. Odor not distinctive.

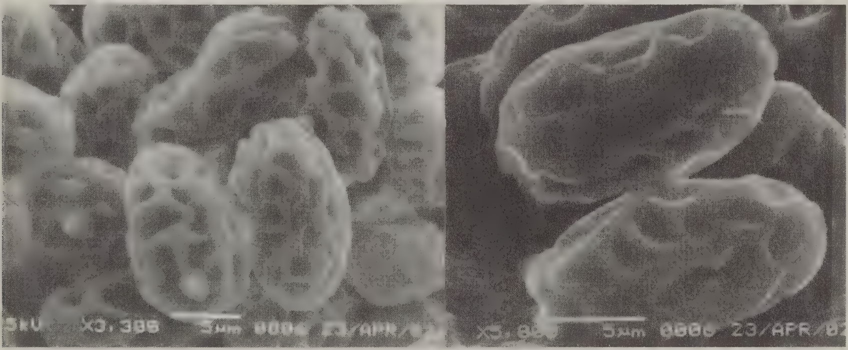

Plate. 2 Scanning Electron Micrographs of Spores of *Heimiella retispora* (HKAS 32686)

Spores (including ornamentation) [80/4/4] (14.5-)16.0 -19.0(-25.0) × (9.5-)10.5-13.0 (-14.0) μm, spores body (excluding ornamentation) [69/4/4] (12.0-)12.5-16.0(-22.0) × (7.0-)7.5-10.0(-11.0) μm, broadly elliptical, with irregular ridges and meshes, golden yellowish brown. Basidia 32.0-40.0 × 13.0-15.0 μm, 4-spored, clavate. Pleurocystidia (60-)80.0-120.0 × 12.0-20.0 μm, scattered, attenuate towards the apex, thin-walled. Cheilocystidia 33.0-55.0 × 7.0-12.0μm, numerous, clavate to subfusoid, most hyaline, some with yellowish content, thin-walled, forming sterile edge on the pores.

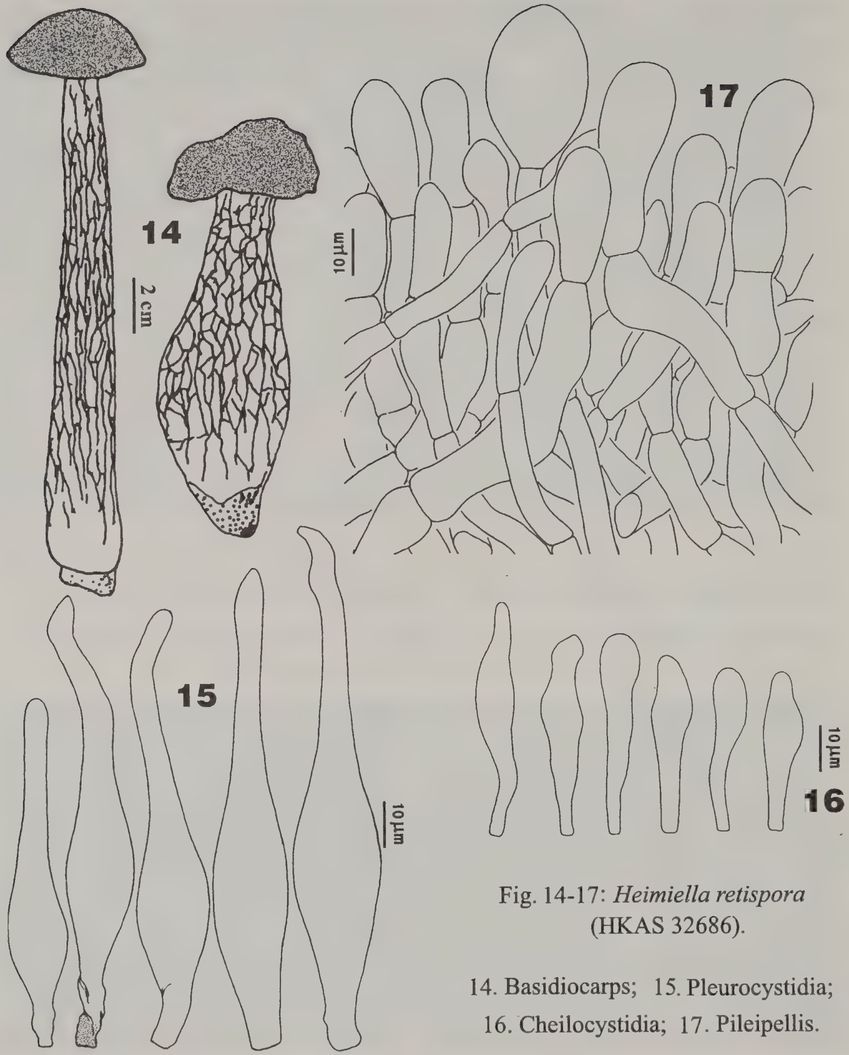

Fig. 14-17: *Heimiella retispora* (HKAS 32686).

14. Basidiocarps; 15. Pleurocystidia; 16. Cheilocystidia; 17. Pileipellis.

Pileipellis with a pile of moniliform hyphal ends, about 80-100 µm thick, the terminal cells clavate to cylindric, 20-40 µm long, 6-15(-22) µm wide.

Specimens Examined: Kunming, Miaogaosi ("Miaokaotze"), 7. VIII. 1942, W. F. Chiu 7865 (HKAS 3865); Kunming, Xishan ("Shishan"), 12. VII. 1943, W. F. Chiu 8205 (HKAS 4205); Chuxiong, 22. VIII. 1983, W. K. Zheng 83402 (HKAS 12033); Kunming markets, 22. VI. 1998, X. H. Wang 268 (HKAS 32684); Kunming market, 23. VI. 1998, X. H. Wang 271 (HKAS 32685); Songming markets, 29. VI. 1998, X. H. Wang 281 (HKAS 32686).

Hab.: On soil in mixed or coniferous forests.

Note: The above description was drawn from several collections obtained from the markets in Central Yunnan. It agrees with Chiu's *B. retisporus*. These Yunnan specimens bear much larger spores than those of

Corner's (1972) and the type measured by Singer (1945). The pileipellis is also somewhat different with that illustrated by Corner (1972). However, they are identical with *H. retispora* in the other points.

Boedijn (1951) suspected that Chiu's collections were not the same as his *H. retispora* and Corner (1972) suggested that Chiu's might be *H. subretispora* Corner. We think that Boedijn's collection is more similar to *H. mandarina* Corner with the brownish basidiomes, pileus with acute umbo and reflexed margin and nearly smooth stipe. Although the spores of Chiu's specimens are much larger, *Strobilomyces retisporus sensu* W.F. Chiu is not *H. subretispora* because the pileus and stipe are wholly reddish rather than brownish, the stipe is coarsely reticulate rather than longitudinally striated and the stipe apex is clear yellowish rather than reddish.

Among the specimens examined, HKAS 32685 bear much smaller spores, a character similar to *H. japonica* Hongo. However, sphaerocysts, the most diagnostic character of *H. japonica* (Hongo, 1969), were not found in the pileus surface of HKAS 32685.

This species was encountered in the markets in Central Yunnan mixed with other edible boleti such as *B. speciosus* Frost and *B. rubellus sensu* W.F. Chiu. Some local people regarded it as poisonous. It may be one of the fungi causing intoxication.

4. *Leccinum extremiorientale* (L. Vass.) Singer, Agar. Mod. Tax. 2nd Ed. 744 (1962).

Boletus crocipodius sensu W.F. Chiu, Mycologia **40(2):** 195 (1948), non Letel.

Leccinum rugosiceps sensu J.Z. Ying *et al.*, Edible Mushrooms (1982), non Peck.

Specimens Examined: Anning market, 5. IX. 1997, X. H. Wang 81 (HKAS 31667); Kunming market, 26. VIII. 1997, X. H. Wang 9 (HKAS 31670); Lufeng market, 10. VI. 1998, X. H. Wang 238 (HKAS 32703); Songming market, 17. VI. 1998, X. H. Wang 243 (HKAS 32810); Nanhua market, 27. VII. 1998, X. H. Wang 450 (HKAS 32811).

Hab.: On soil in coniferous forests.

Note: This is one of the most famous delicious mushrooms sold in large quantity in Yunnan especially Central Yunnan markets. The robust basidiome, the velvety and radially cracked grooved pileus, the projecting pileus margin, the yellowish and minute pores and the densely punctate stipe make it easily recognized. The collections both cited by Chiu and collected by us agree perfectly with the description given by Hongo (1976a).

This fungus was first regarded as *Boletus crocipodius* Letel. by Chiu (1948) and later as *L. rugosiceps* (Peck) Singer by Ying *et al.* (1982: 187-188). Thereafter the two names, as well as *L. extremiorientale*, were used for the same mushroom (see Ying & Zang, 1994: 259-264; Zang, 1991b: 215-217; Zhang, 1999: 70). In fact the differences between the three species are obvious (see Imazeki & Hongo, 1979: 100, Smith & Thiers, 1971: 216-217). *L. extremiorientale* is the proper name for this eastern Asian fungus.

ACKNOWLEDGMENTS

The SEM photographs of *Boletellus puniceus* and *Boletus megasporus* in this paper were prepared by Dr. E. Horak, Herbarium ZT, Zürich. We are very grateful to Dr. Y. Doi, National Science Museum, Japan for the loan of type specimens. We thank Prof. M. Zang and Dr. Zhu. L. Yang, Kunming Institute of Botany, China, for providing valuable literatures and suggestion. We also express our sincere gratitude to Dr. E. Horak and Dr. R. Halling, the New York Botanical Garden, Bronx, New York, for critically reviewing the manuscript.

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GEASTRUM SETIFERUM (GASTEROMYCETES): A NEW SPECIES WITH A SETOSE ENDOPERIDIUM

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ABSTRACT - *Geastrum setiferum*, found on soil from the Brazilian cerrado region (State of São Paulo) and caatinga region (State of Pernambuco) respectively, is described and illustrated. This taxon is distinguished by its epigeous basidiomata with a setose endoperidium and small spores. Pictures of the capillitium and spore ornamentation under SEM are added.

KEYWORDS: Lycoperdales, Geastraceae, taxonomy.

INTRODUCTION

During several incursions on the Brazilian regions, we have studied some collections pertaining to the genus *Geastrum* Persoon, that did not match any of the described species in the literature such as the works of Lloyd, 1901; 1902; 1907; Rick, 1910; 1930; 1961; Long, 1917; Coker & Couch, 1928; Bottomley, 1948; Cunningham, 1944; Ponce de Leon, 1946; 1968; Long & Stouffer, 1948; Eckblad, 1955; Dissing & Lange, 1962; Dring & Rayss, 1963; Dring, 1964; Demoulin, 1968; Calonge & Demoulin, 1975; Smith & Ponce de Leon, 1982; Dörfelt & Müller-Uri, 1984; Liu, 1984; Sunhede, 1989; Moyersoen & Demoulin, 1996; Calonge, 1998 and Soto & Wright, 2000. For this reason we have decided to propose *Geastrum setiferum* as a new species.

MATERIALS AND METHODS

Fieldworks have been made in the Ecological Station of Jataí (State of São Paulo) and Biological Reserve of Serra Negra (State of Pernambuco) during the rainy season. These areas are characterized by seasonal but moderately deciduous forest. Climatic conditions are of the AW and BSh type respectively, according to Köppen System (Andrade-Lima, 1981; Eiten, 1993).

The morphological description is based on seventeen specimens. Hand-cut sections of fresh and dried material were mounted for light-microscope (LM) examination in 2% KOH with cotton blue (Sunhede, 1989). Spores were air-dried, mounted on aluminium stubs, sputter coated with gold and examined in a Philips XL 20 scanning electron microscope (SEM). Color terms in parenthesis are those of Kornerup & Wanscher (1978), indicated as KW. Herbarium abbreviations are according to Holmgren *et al.* (1991). The material was preserved at the Herbarium Maria Eneyda P. K. Fidalgo (SP) and Camille Torrend (URM).

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RESULTS

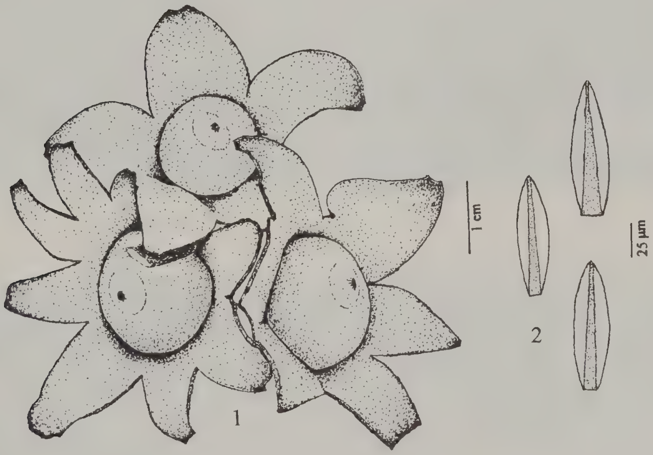
Geastrum setiferum Baseia sp. nov.
Figs. 1-4
Carposomata juvene epigaeum, adhuc clausum globulare vel depresse globulare, 1.5-2.3 cm latum. Exoperidio apertum 3-5 cm latum in 5-8 radios acutos, recurvos fissum; stratum myceliale fulvum, squamosum, squamatim deciduum; stratum medium fulvum, tenue; stratum internum carneum, tenue, persistens. Endoperidio ex setis, carneum, sessile, globulare, 1-2 cm latum, setis cimbiformis 90-120 x 23-30 μm, brunneis; peristomio determinato, fibrilloso, fere sulcato. Gleba brunnea; columella parva manifesta; sporis globosis, 2.5-3 μm latum, brunneis, valde verrucosis sub lente; sub microscopio eletronico dense verrucosis, verrusis colunaris majores et minores; capillitio longis, 3-4 μm latum, brunneis, frustulis paulum incrustatum, aseptatum, non ramificatum.

In silvis ad terram, rarus. Holotypus: Brazil, São Paulo, Ecological Station of Jataí, 17/I/2002, leg. Baseia 1450, in Herb. SP n° 307595 conservatus est.; isotypus: in Herb. URM n° 77072; paratypus: in Herb. URM n° 77077.

Basidiomata epigeous when young, globose to depressed-globose, 1.5-2.3 cm broad. Exoperidium when open 3-5 cm broad, split into 5-8 acute, recurving rays; mycelial layer yellowish-brown KW-5F6, squamose, tending to peel off in flakes; medium layer yellowish-brown KW-5F5, thin; inner layer brownish-orange KW-7C5, thin, persistent. Endoperidium setose, greyish-orange KW-5B3, sessile, globose, 1-2 cm broad, setae cymbiform 90-120 x 20-30 μm broad, brown; peristome definite, fibrillose to almost sulcate; columella distinct; spores globose, 2.5-3 μm broad, brown, strongly ornamented, appearing verrucose under LM; under SEM the ornamentation is seen as densely arranged, column-shape warts and among them, much smaller ones; capillitium hypha long, 3-4 μm broad, brown, slightly incrusted with debris, aseptate, not branching.
Material studied: holotype, isotype and paratype.
Habitat: Groups on soil in proximity to *Chloroleucon foliolosum* (Benth.) G. P. Lewis and *Jacaranda cuspidifolia* Mart.
Distribution: Brazil, States of São Paulo and Pernambuco.
Remarks: Further study revealed it to be a well defined new species of *Geastrum*. In this group the spores usually vary between 3 and 8 μm diam. *Geastrum setiferum* is fundamentally recognized by the following characters: epigeous basidiomata, setose endoperidium and small spores, measuring 2.5-3 μm diam. (ornamentation included) and their distinct ornamentation under SEM, that is seen as densely arranged, column-shape warts and among them, much smaller ones.

Geastrum setiferum and *G. smardae* Stanek have some characteristics in common; both are rather medium sized species with umbonate, epigeal unexpanded basidiomata and the type of spore ornamentation. There are, however several dissimilarities: *G. setiferum* has an endoperidium with large cymbiforms setae (90-120 µm), a distinctly delimited peristome and smaller spore size. *G. hieronymii* (Henn.) P. Ponce recalls *G. setiferum*, but differs by the endoperidium covered by acute or subpyramidal spicules and larger spores (3.5-6µm diam.).

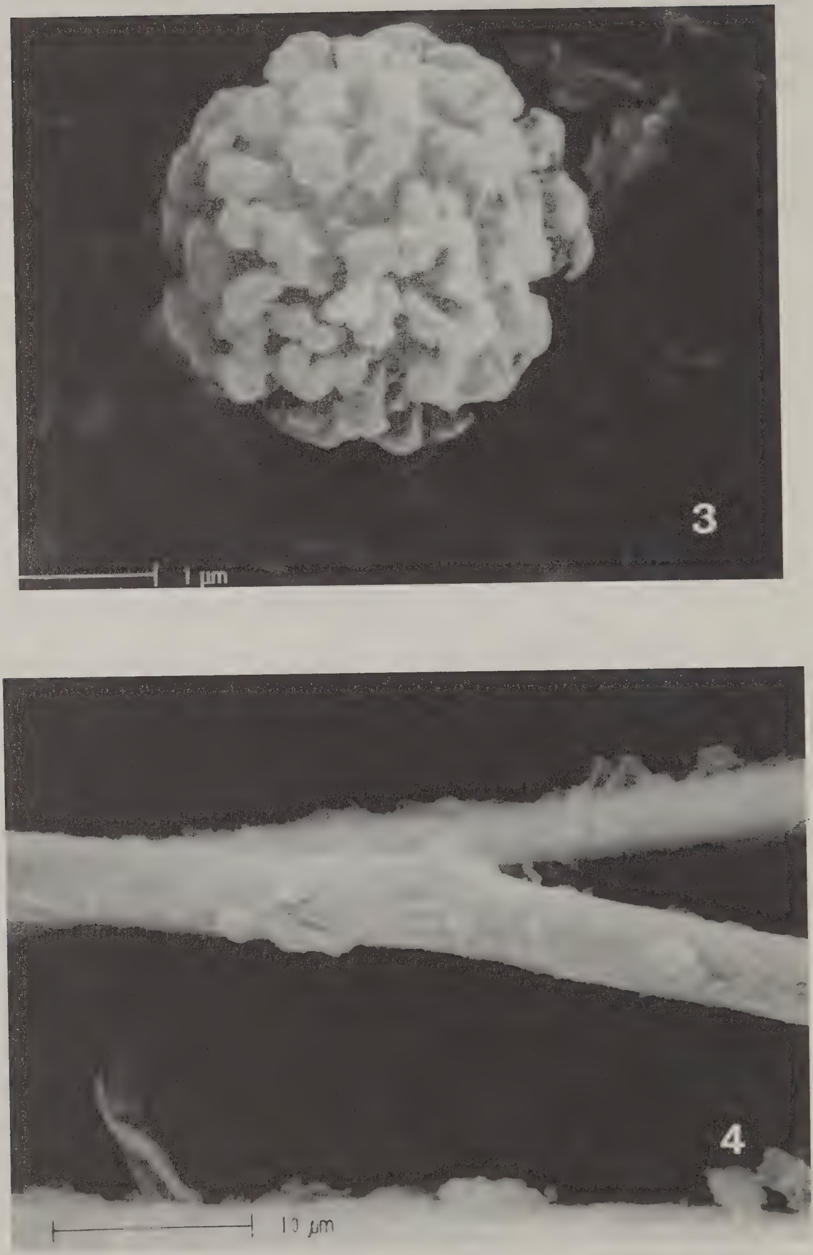
Geasteroides barbata (Dissing & Lange) P. Ponce, another similar species with setose endoperidium found in the Africa, differs fundamentally by the presence of a prominent sterile base, deciduous endoperidium with the branched and septate capillitium characterizing this genus. In our opinion these properties strongly support *Geastrum setiferum* as a new taxon.



Figs 1-2. *Geastrum setiferum*: 1. general aspect of mature basidiomata; 2. cymbiform setae under LM.

ACKNOWLEDGMENTS

We acknowledge the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), of Brazil, for partially supporting this work. We also thank Dr. J. E. Wright and Dr. F. Calonge for critically reviewing this paper.



Figs 3-4. Photomicrographs of spore and capillitium under SEM (Holotype): 3. spore with irregular short warts; 4. capillitial hypha slightly incrusted with debris.

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MYCOTAXON

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MYCODIVERSITY STUDIES IN SELECTED ECOSYSTEMS OF GREECE: III. MACROFUNGI RECORDED IN QUERCUS FORESTS FROM SOUTHERN PELOPONNESE

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Abstract: Only fragmentary data were available until now on macrofungi associated with oak forests in Greece, and similarly there is very scarce information on the mycological flora of Peloponnese. The present research study comprises a detailed inventory of Basidiomycotina and larger Ascomycotina, which are associated with oak (mainly *Quercus frainetto* and *Q. pubescens*) in the southern part of this region. It resulted in the recording of 197 species belonging in 86 genera (192 species and 83 genera of Basidiomycotina, and 5 species and 3 genera) to Ascomycotina), among which 43 species or subspecific taxa and 1 genus (i.e. *Xenasma*) are reported for the first time from Greece. In addition, other 110 taxa records constitute new substrate/hosts reports. Taxonomic notes and descriptions are provided for the most interesting findings, and an analysis of relevant information is presented in conjunction to ecotrophic preferences, spatial and time occurrence, and habitat.

Key-words: mycoflora, macromycetes, mushroom, oak, Basidiomycotina

INTRODUCTION

About one third of the Greek forest vegetation is composed of broad-leaved deciduous forests, and 76.3% of the latter (or approx. 1.5 million hectares) corresponds to oak forests (National Forest Service: Inventory of Greek Forests, 1991). In Peloponnese, forests with deciduous *Quercus* occur at altitudes of 200-900 m and cover approx. 101,000 hectares (ca. 10% of the total forest area). Their main part is located in the southern part of the peninsula, in the prefectures of Arkadia and Messinia. This larger region is classified within the para-Mediterranean *Quercetalia pubescentis* phytosociety (*Quercion confertae* sub-alleance), which extends throughout continental Greece, presenting a weak mid-mediterranean to sub-mediterranean bioclimatic type with soils characterized as Luvisols and Cambisols. *Quercus frainetto* Ten. is the dominant species often forming mixed groups (as well as hybrids) with *Quercus pubescens* Willd. s.l.

These particular ecosystems of Peloponnese have not been studied until now as regards their fungal biodiversity, whereas there are very few scattered data available on the occurrence of macromycetes associated with oak in Greece (Maire & Politis 1940, Minter 1988, Diamandis 1992).

In the frame of an ongoing project aiming at inventorying the Greek mycodiversity, available literature data permitted an estimation of only 2,500 recorded fungal species (Zervakis

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2001, Zervakis & Dimou 2000), which in conjunction with the compiled check-lists of Basidiomycotina and larger Ascomycetes (Zervakis & al. 1998, Zervakis & al. 1999), provide the basis for further work on macrofungi. This is the third in a series of initial reports from the surveys conducted during the recent past on selected biotopes and the first mycological data ever published following a several years-long research study in *Quercus* forests of Peloponnese.

METHODOLOGY

Foraying and collecting of fungal specimens was carried out during five consecutive years (from late August until early June of the years 1996-97, 1997-98, 1998-99, 1999-2000 and 2000-2001). Four selected sites, each one of an estimated total area of 1 sq.km. (Fig. 1), were frequently visited (at least two-three times per month) and thoroughly investigated:

Site 1 (S1): along the road from Dyrrachi to Leontari (direction north-northwest, 1 km), altitude 800 m, coordinates 37°12′38′′N-22°10′39′′E, vegetation primarily consisting of *Quercus frainetto* interspersed with *Q. pubescens*, *Q. coccifera*, other evergreen shrubs, and a few *Abies cephalonica*, *Juniperus oxycedrus* ssp. *oxycedrus*, *Platanus orientalis* and *Prunus* spp. trees. It belongs to the Tripolis zone with flysch undivided: alternations of grey marts, sandstones with intercalations or lenses of limestones and conglomerates (Upper Eocene-Oligocene), and dolomite-bedded limestones: grey, bituminous, medium-bedded, sometimes dolomitized (Paleocene-Upper Eocene).

Site 1* (S1*): along the same road as before, 1 km north-northeast of S1, altitude 750 m, vegetation primarily consisting of *Quercus frainetto* interspersed with *Q. pubescens*, *Q. coccifera*, other evergreen shrubs, and a few *Malus domesticus*, *Crataegus monogyna*, *Platanus orientalis* and *Prunus amygdaliformis* trees. Geological data as before.

Paradeisia: along the road from Paradeisia to Megalopoli, 1 km north-northwest of the Paradeisia village (in the vicinity of the railway station), altitude 500 m, coordinates 37°19′47′′N-22°04′29′′E, vegetation primarily consisting of *Q. frainetto* and *Q. pubescens* (and their hybrids) interspersed with *Fraxinus ornus*, *Q. ilex*, *Q. coccifera, Cistus incanus*, *Carpinus betulus*, *C. orientalis*, *Ostrya carpinifolia*, *Phillyrea media*, *Genista acanthoclada*, etc. Geological data as before.

Megalopoli: along the national road from Kalamata to Megalopoli, 50 km north of Kalamata, altitude 500 m, coordinates 37°21′14′′N-22°06′54′′E, primarily consisting of *Q. frainetto* and *Q. pubescens* (and their hybrids) interspersed with *Q. coccifera, Cistus incanus*, *Genista acanthoclada*, etc. Geological data as before.

In addition, several other records made either from the Arkadia prefecture (i.e. Isaris, Leontari, Agia Theodora, Agioi Apostoloi, Dyrrachi, Chrysovitsi, Karnasi, Agioi Anargyroi) or from Messinia (i.e. Chrysochori, Exochori, Proastio, Saïdona, Neochori, Koskaraka gorge, Nedon gorge) are included in this report and indicated in Fig. 1.

The Meteorological Station which is closest to the investigated oak forests of Arkadia (3-10 km north to northwest of all four major sites mentioned above) is operated by the Thermoelectric Plant of the State Electric Company ("DEI"). However, DEI refused to provide us data on local weather conditions during the period of the study, although these were officially requested from our side. As regards the investigated *Quercus* woods in Messinia (e.g. Exochori or Chrysochori), data from the closest Meteorological Station (located at the Kalamata airport) are not representative and thus not suitable for quotation.

Field parameters and macroscopic characteristics of the collected specimens were recorded *in situ*. Microscopic observations and microchemical reactions were carried out at the National Agricultural Research Foundation, Institute of Kalamata (NAGREF-IK). Additional examinations were performed (where needed) in the Laboratory of General & Agricultural Microbiology at the Agricultural University of Athens (LGAM-AUA). For the identification, field books, general and specialized keys and monographs were used (e.g. Dennis 1981, Singer

1986, Moser 1983, van Waveren 1985, Ryvarden & Gilbertson 1993, Breitenbach & Kränzlin 1984-2000, Bas & al. 1988-1995, Hansen & Knudsen 1992, 1997, Eriksson & Ryvarden 1973-1976, Eriksson & al. 1978-1984, Hjortstam & al. 1987-1988, Jülich 1984, Pegler & al. 1995).

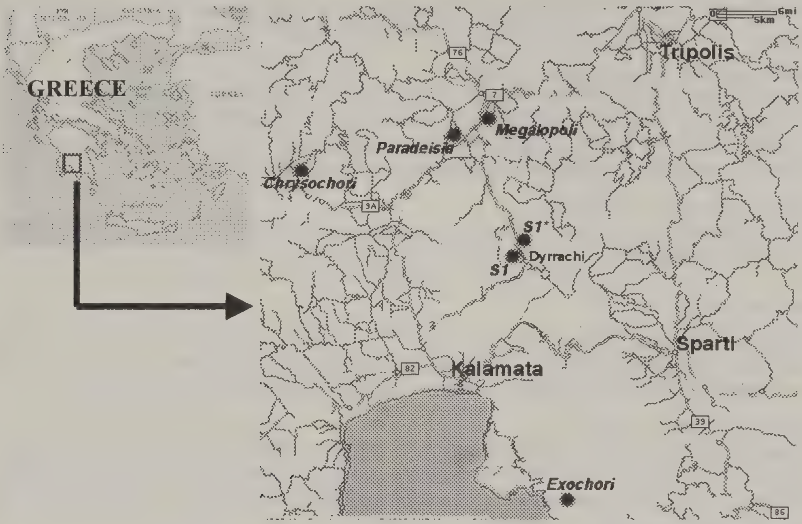

Fig. 1. Map illustrating the region of southern Peloponnese (Greece) which was examined for macrofungal diversity, and indicating by dots the position of major sites where a more detailed study was conducted.

The species are presented in alphabetical order within each genus. Nomenclature follows in most cases the guidelines of the Dictionary of Fungi (Hawksworth & al. 1995). When necessary, comments follow each species citation. Taxa reported for the first time from Greece are marked by an asterisk (*), while new habitat or host/substrate records for Greece are marked by a cross (†). All species cited in this study are deposited in the herbarium of the NAGREF-IK. A photographic archive is also maintained, and pure cultures are available for certain specimens.

The Greek geographical names are those used in the current language ("dimotiki") and their transcription into English follows the international standard ISO 843 (IOS 1997).

DATA RECORDED

Ascomycotina

†***Helvella acetabulum*** (L.) Quél.
In *Quercus frainetto* (S1) and in *Quercus coccifera* forests (Paradeisia), gregarious, uncommon, April-May. Only two previous records from Greece in *Pinus nigra* (Diamandis 1985) and *Castanea sativa* (Diamandis 1992).

†***Helvella crispa*** Scop.
In *Q. coccifera* (Proastio), and in *Q. frainetto* and *Quercus pubescens* forests (Paradeisia), solitary or in small groups, rather common, November-December. Common in Greece (Zervakis

& al. 1999); however, the mixed *Q. frainetto* and *Q. pubescens* forest in Paradeisia is a new habitat record.

Helvella queletii Bres.
In *Q. frainetto* and *Q. pubescens* forests, uncommon, in small groups, May 1999 (S1). This forms the only report so far from Greece (Zervakis & al. 1999).

†***Melittosporium versicolor*** (Fr.) Corda
On rotten wood of *Quercus ilex*, December 1999 (Nedon gorge). Apothecia of this fungus are up to 5 mm in size and are embedded in the wood surface or in the bark. Asci 8-spored, tips not bluing in Melzer's reagent, ascospores cylindric, non septate, 18-24 x 5-7 μm. One previous record on *Q. coccifera* as *Propolis versicolor* Fr. (Maire & Politis 1940).

†***Otidea bufonia*** (Pers.) Boud.
In *Q. frainetto* forests, in small groups, rather common, October-November (S1, Chrysochori). Uncommon in Greece.

Basidiomycotina

†***Agaricus augustus*** Fr.
In *Q. frainetto* forest clearings, gregarious, rare, September-October 1996 (S1). Reported only once before from Greece in *Q. pubescens* forest clearings (Diamandis & Perlerou 1990).

†***Agaricus pampeanus*** Speg.
In meadows with manure, gregarious, abundant, October 2000 (S1*). Previously recorded in *Fagus sylvatica* in Mt. Oxya (Dimou & al. 2002), and in grassy clearings of mixed *Q. coccifera* and *Abies cephalonica* woods in Mt. Taygetos (Zervakis & al., submitted).

†***Agaricus placomyces*** Peck
In *Q. frainetto* forests, in small groups, rare, September-October 1999 (S1*). There was only one record in the past in evergreen broadleaved forests (Diamandis 1985).

****Agaricus porphyrizon*** Orton
On soil humus in *Q. frainetto* forests, in small groups, uncommon, November to early December 1999 (S1*). Recorded only once before in *Cupressus sempervirens* in Andros island (Polemis 1998).

****Agaricus romagnesii*** Wass.
On bare soil under *Platanus orientalis* in *Q. frainetto* forest, in small clusters, rare, collected once in October 2000 (S1*). Diagnostic features of this taxon are the presence of a rhizoid at the stipe base, brownish concentrically appressed scaly pileus, faint carbonic smell and weak yellow-brown discolouration of flesh. Microscopically, it possesses spores 6.2-8.3 x 3.5-4.5 μm, and basidiole-like cheilocystidia, 17-31 x 7-11 μm (Cappelli 1984).

****Agaricus semotus*** Fr.
In *Q. frainetto* forests, in small clusters, not common, collected once in September 1999 (S1*). Our specimens possessed both macro- and microscopic features which fit with accuracy the original description by Fries (Cappelli 1984). Basidiomata are of small size (up to 4 cm), pileus wine-red minutely squamulose in a white background and with a low umbo, stipe clavate staining yellow towards the base when bruished, smell of almonds, spores 4-5 x 3-3.8 μm, and cheilocystidia broadly clavate to vesiculose, 8-16 μm broad.

Agrocybe praecox (Pers.) Fayod
In a meadow, solitary, not common, May 1999 (S1*). Previously recorded in fields (Pantidou 1990) and in *F. sylvatica* (Dimou & al. 2002).

****Aleurodiscus disciformis*** (DC.) J. Schröt.
On the bark of *Q. frainetto* trunk, rare, December 1999 (S1*). Basidiomata resupinate, effuso-reflexed, hymenium cream coloured, acanthohyphidia and dendrohyphidia absent, cystidia with

moniliform apex abundantly covered by crystals, spores amyloid, with rounded warts, 12-18 x 10-14 µm (Eriksson & Ryvarden 1973, Breitenbach & Kränzlin 1986).

Amanita caesarea (Scop.) Pers.
In *Q. frainetto* and *Q. pubescens* forests, in groups, widespread but rather uncommon, September-October (S1, Paradeisia). Widespread in Greece.

*****Amanita ceciliae*** (Berk. & Br.) Bas
In *Q. frainetto* and *Q. pubescens* forests, in small groups, uncommon, October-November (S1*, Megalopoli). Typical features of this robust vaginate amanita are the gray-brown pileus with striate margin covered by patches of veil remnants, which are grey when young and brownish when old, and the volva consisting of 2-3 multiple grey-brown zones (Breitenbach & Kränzlin 1995).

Amanita citrina (Schaeff.) Gray
In *Q. frainetto* and *Q. pubescens* forests, solitary, rather uncommon, September-October 1996 and 1997 (S1, S1*, Paradeisia, Exochori). Common in Greece.

† ***Amanita crocea*** (Quél.) Singer
In *Q. frainetto* and *Q. pubescens* forests, solitary, rare, collected once in September 1999 (S1*). Previously recorded by Maire & Politis (1940) in *Quercus* sp. as *A. vaginata* (Fr.) Quél. var. *crocea* Bourd., and in Andros island in *Quercus* sp. and *Q. ilex* (Zervakis & al. 1998).

*****Amanita excelsa*** (Fr.) Bertillon
In a mixed forest of *Q frainetto*, *Q. pubescens*, *Carpinus betulus* and shrubs, solitary, rare, October-November 1996 (Megalopoli, Chrysochori). A morphologically variable species; our specimens resemble *A. excelsa* var. *excelsa* (sensu Breitenbach & Kränzlin 1995) in rooting deeply in the ground, without a bulb and with an odour of potatoes.

†***Amanita franchetii*** (Boud.) Fayod
In *Q. coccifera* forests, solitary, uncommon, November 1999 (Isaris, S1*). Previously reported in *F. sylvatica* from Mt. Oxya (Dimou & al. 2002), and *P. nigra* and *A. cephalonica* from Mt. Taygetos (Zervakis & al., submitted).

†***Amanita mairei*** Foley
In *Q. frainetto* and *Q. pubescens* forests, solitary, rather common, October-November (Megalopoli, Paradeisia). Recorded also in mixed *Q. coccifera* and *A. cephalonica* (Zervakis & al., submitted).

Amanita pantherina (DC.) Krombh.
In *Q. frainetto* and *Q. pubescens* forests, solitary, rather common, October (Paradeisia). Common in Greece.

Amanita phalloides (Vaill.) Link
In *Q. frainetto* and *Q. pubescens* forests, in small groups, rather rare, September-October 1996 and 1997 (S1, Paradeisia). Few previous records from Greece, only in hardwood forests (Pantidou 1990, Diamandis 1992, Zervakis & al. 1998).

Amanita rubescens (Pers.) Gray
In *Q. frainetto* and *Q. pubescens* forests, in large groups, common, September to early November (S1, Paradeisia). Common in Greece.

†***Amanita solitaria*** (Bull.) Mérat
In *Q. frainetto* and *Q. pubescens* forests, solitary, rather rare, September-October 1999 (Paradeisia). It was reported only once before in Greece from *Quercus aegilops* and *Q. ilex* forests (Diamandis & Perlerou 1990).

Amanita vaginata (Bull.) Vittad.
In *Q. frainetto* and *Q. pubescens* forests, solitary or in small groups, rather common, September - early November (S1, Megalopoli, Paradeisia). Common in Greece, it was reported only from hardwood forests (Pantidou 1990, Diamandis 1992, Zervakis & al. 1998).

†***Amanita verna*** (Fr.) Vittad. ss. auct.
In *Q. frainetto* and *Q. pubescens* forests, in small groups, rare, October-November 1998 (Chrysochori). Relatively common in Greece, recorded only in coniferous forests as *A. virosa* (Fr.) Bertilloni (Zervakis & al. 1998).

†***Armillaria mellea*** (Vahl) P. Kummer
On living *Q. frainetto* and *Q. pubescens* trees, in large clusters, common, September to early November (S1, Paradeisia). Although widespread in Greece on numerous hosts (Zervakis & al. 1998, Tsopelas 1999), this is the first record on *Q. pubescens*.

†***Armillaria tabescens*** (Scop.) Emel.
On living *Q. frainetto* and in *Q. pubescens* trees, in clusters, rather common, September to early November (Megalopoli). Rare in Greece, previously reported from Mt. Oiti (central Greece) on *Q. frainetto*, *A. cephalonica* and in almond orchards (Tsopelas 1999). This is the first host record for *Q. pubescens*.

†***Auricularia auricula-judae*** (Bull.) Wettst.
On *Acacia* sp. living trunk (Paradeisia), and on unidentified dead hardwood (Exochori), common, November. Common throughout Greece on various hosts.

†***Auricularia mesenterica*** (Dicks.) Pers.
On rotten log of *Juglans regia*, uncommon, March 2000 (Agia Theodora). Common in Greece on various hosts.

†***Bjerkandera adusta*** (Willd.) Karst.
On the wood of a living *P. orientalis* tree by the ground, uncommon, October-November 1998 (S1*). Rather common in Greece on various hardwoods.

Bolbitius titubans (Bull.) Fr.
In grassy clearings in *Q. frainetto* forest, in small groups, uncommon, September-October 1999 (S1*). Recorded only twice in the past in Greece as *B. vitellinus* (Pers.) Fr. var. *titubans* (Bull.) Fr. (Maire & Politis 1940), and as *B. vitellinus* (Pers.) Fr. (Diamandis 1992).

Boletus aereus Bull.
In *Q. frainetto* forests, in small scattered groups, rare, October 1996 (S1). Few previous reports from Greece in hardwood forests (Zervakis & al. 1998).

†***Boletus appendiculatus*** Schaeff.
In *Q. frainetto* and *Q. coccifera* forests, in small groups, rather common, late September-October 1996 (S1, Nedon gorge). Rather common in Greece reported from various habitats.

****Boletus dupainii*** Boud.
In *Q. coccifera* forest, solitary, rare, October 1996 (S1). This taxon is distinguished by the presence of a dry (at maturity) pileus with deep carmine-red colour, stipe with yellow-beige colour, flesh pale yellow turning blue, spores 12.0-16.0 x 4.3-5.7 µm (Moser 1983).

Boletus edulis Bull.
In *Q. frainetto* forests, solitary or in small groups, rather common, October (S1). Common in Greece in a wide range of habitats.

Boletus fragrans Vittad.
In *Q. frainetto* forests, solitary or in small groups, rare, late September-October 1996 (S1). Recorded only once before in Greece from the same habitat (Diamandis 1985).

† ***Boletus luridiformis*** Rostk.
Solitary, common, in *Q. coccifera*, October (Koskaraka and Nedon gorge); in *Q. frainetto*, September (Karnasi); and in *Q. pubescens*, May 1999 (Paradeisia). Common in Greece, previously reported as *B. erythropus*.

†***Boletus luridus*** Schaeff.
In *Q. frainetto* and *Q. coccifera* forests, solitary, rather common, September-October (S1, Dyrrachi-Neochori). Few previous records in Greece (Zervakis & al. 1998).

Boletus pulverulentus Opat.
In *Q. coccifera* and in *Q. pubescens* (S1*), and in *Q. frainetto* forests (Paradeisia), solitary or in small groups, uncommon, September-October 1999. Only one previous report from Greece in *Q. frainetto* (Diamandis 1992).

†***Boletus queletii*** Schulzer
In *Q. ilex* and *Q. coccifera* forests, solitary or in small groups, uncommon, October - early November 2000 (Nedon gorge). Reported only twice before from Greece (Pantidou 1990, Diamandis 1992).

†***Boletus radicans*** Pers.
In *Q. frainetto* and *Q. coccifera* forests, in small groups, rare, late September-October 1996 (S1), and in *Q. coccifera*, solitary, September 1999 (Chrysovitsi). The combination of macroscopic features, such as light grey-beige pileus, intense lemon-yellow pores that become immediately blue when bruised, fine brown net on stipe surface and bitter taste are typical for this taxon. Only one other report from Greece in *F. sylvatica* (Dimou & al. 2002).

†***Boletus satanas*** Lenz.
In mixed forests of *Q. frainetto* and in *Q. pubescens*, solitary or in small groups, abundant, September-November (Paradeisia, Megalopoli); in *Q. coccifera*, solitary, September-October (Chrysovitsi, Nedon gorge); and in *Q. frainetto*, solitary, September (S1). Only one previous report from Greece in *Q. frainetto* (Diamandis 1983).

†***Botryohypochnus isabellinus*** (Fr.) J. Erikss.
On dead wood of *Q. frainetto*, rare, February 2000 (S1*). It is characterized by the "hypochnoid" resupinate basidiomata, with typical microscopic features such as short-celled hyphae with simple septa, short cylindrical 4-spored basidia and globose basidiospores with prominent spines up to 3 µm. One previous report from Greece in *Fagus* forests (Dimou & al. 2002).

Calocera cornea (Batsch) Fr.
On dead wood of *Q. frainetto*, common, October-November (Exochori, Paradeisia-Megalopoli). Common in Greece on various hardwoods.

†***Camarophyllus niveus*** (Wulf.) P. Kummer
On grass in *Q. frainetto* forests, rare, November-December 1996 (S1*). Two previous reports in Greece as *Hygrocybe nivea* (Scop.) Fr. (Maire & Politis 1940, Diamandis 1992); collected also in coniferous forests of Mt. Taygetos (Zervakis & al., submitted).

Cantharellus cibarius Fr.
In *Q. frainetto* forests, solitary or in small groups, uncommon, October 1996 (S1*). Common in Greece in a wide range of habitats.

Cerocorticium molare (Chaillet) Jülich & Stalpers
On dead branches on standing *Q. frainetto* trees, uncommon, October-November 1998 (Paradeisia-Megalopoli). Two previous reports from Greece on the same host (Maire & Politis 1940, as *Radulomyces molaris* (Chaillet) M.P. Christ.; Diamandis & Perlerou 1990).

†***Cerrena unicolor*** (Fr.) Murrill
On logs of *Q. frainetto*, rather common, August-September (S1). Few records from Greece on hardwoods (Zervakis & al. 1998).

†***Clathrus ruber*** Pers.
In *Q. coccifera* and *Q. pubescens* forests, solitary, rare, late November-December 1997 (Exochori-Saïdona) and December 1999 (S1*). Only two previous reports from Greece (Diamandis 1992, Zervakis & al. 1998).

†***Clavariadelphus pistillaris*** (Fr.) Donk
On leaves and humus of *Q. coccifera* forest, and other evergreen shrubs, solitary, rare, December 1996 (Koskaraka). Three previous reports from central and northern Greece (Diamandis & Perlerou 1994, Zervakis & al. 1998, Dimou & al. 2002).

****Clavulina amethystina*** Fr.: Donk
In *Q. coccifera* forest, and other evergreen shrubs, solitary, rare, December 1996 (Koskaraka). This taxon is characterized by its violet colours and the size of basidiocarp (our specimens are 2-3 cm high). *C. cinerea* can also sometimes present similar colours, but its basidiomata are much bigger: 3-10 cm (Jülich 1984). Additionally, our specimens possessed spores 7-12(13) x 6-9 μm and basidia 45-65 x 6-8 μm with basal clamp.

Clavulina cinerea (Fr.) Schroet.
On leaves and humus in *Q. frainetto*, rather rare, October-November 1998 (Paradeisia). Only one previous record in Greece from mixed forests of *Carpinus betulus* and *Abies borisii-regis*, and *Q. frainetto* and *P. nigra* (Diamandis 1992).

****Clavulinopsis corniculata*** (Schaeff..) Corner **f. *corniculata***
In *Q. frainetto* forests, in groups, rather rare, December 1999 and March 2000 (S1*). Basidiomata yellow to yellow-brown, up to 5 cm in size, with multiple dichotomous branching always bifurcate at apex.

Clitocybe clavipes (Pers.) P. Kummer
In *Q. frainetto* forests, in groups, common, September-October (S1). Common in Greece in a variety of habitats.

†***Clitocybe dealbata*** (Sowerby) P. Kummer
In grassy manured meadows, edges and clearings in *Q. frainetto* forest, gregarious, September–December 1999 (S1*). Three previous reports in *Pinus brutia* (Diamandis & Perlerou 1990), in fields as *C. rivulosa* (Pers.) P. Kummer (Diamandis 1992), and in mixed forests of *A. cephalonica* and *P. nigra* (Athanasiou & Theochari 1999).

Clitocybe geotropa (Bull.) Quél.
In *Q. frainetto* and in *Q. pubescens* forests, in groups, common, September-October (S1, Paradeisia). Common in Greece in a variety of habitats.

Clitocybe gibba (Pers.) P. Kummer
In *Q. frainetto* and *Q. pubescens* forests, in groups, common, September-October (S1, S1*). Common in Greece in a variety of habitats.

Clitocybe odora (Fr.) P. Kummer
In *Q. frainetto* forests, in groups, common, September-December (S1). Common in Greece in a variety of habitats.

****Collybia aquosa*** (Bull.) P. Kummer
On soil among leaf litter in *Q. frainetto* forests, gregarious, May 1999 (S1*). This taxon is very close to *C. dryophila* (Bull.) P. Kummer resembling macroscopicaly pale forms of it. However, several features such as the combination of light colours (ochre to buff), inflated cheilocystidia, bulbose stipe base and ochraceus rhizomorphs are of diagnostic value (Vilgalys & Miller 1987).

Collybia butyracea (Bull.) P. Kummer
On leaf litter in *Q. frainetto* forests, gregarious, May 1999 (S1*). Common in Greece.

Collybia peronata (Bolt.) Singer
On leaf litter in *Q. coccifera*, *Q. ilex* and *Platanus orientalis* mixed forest, solitary or in groups, uncommon, October-November 2000 (Nedon gorge). The distinct burning hot taste of this taxon facilitates identification.

Coprinus domesticus (Bolt.) Gray
On and around a rotten trunk of *Juglans regia*, rare, March 2000 (Agia Theodora). One other previous record on *J. regia* (Dimou & al., unpublished results).

†***Coprinus lagopus*** (Fr.) Fr.
In *Q. frainetto* forest clearings, rather common, October 1996 (S1, S1*). Few previous records from Greece (Diamandis 1992, Zervakis & al. 1998).

†***Coprinus micaceus*** (Bull.) Fr.
On the dead base of *Q. frainetto* trunks, rather uncommon, May 1999 (Paradeisia). Common in Greece in hardwood forests.

Coprinus picaceus (Bull.) Gray
In *Q. frainetto* forests, solitary, common, October-November (S1, S1*, Paradeisia, Megalopoli). Common in Greece.

†***Coprinus plicatilis*** (Curt.) Fr.
On wood in *Q. frainetto* forests, rare, October-November 1998 (S1*). Reported only twice in the past from Greece (Maire & Politis 1940, Diamandis 1992).

****Corticium polygonoides*** P. Karst.
On rotten stump of *Q. frainetto*, rare, December 1999 (S1*). Basidiomata smooth, resupinate white to violaceous, cystidia absent, dendrohyphidia present, hyphae richly encrusted, spores ellipsoid, smooth, non amyloid, 6.5-9.0 x 4.0-4.5 (Hansen & Knudsen 1997).

****Cortinarius aleuriosmus*** Maire
In *Q. frainetto* forests, solitary, rare, collected once in December 1999 (S1*). Our specimens possessed typical features of subgenus *Phlegmacium*, section *Rapacei*, distinct floury smell and amygdaliform spores (measured 8.5-11 x 5-6 μm). Identification was based on Moser's description (1983).

****Cortinarius anomalus*** (Fr.) Fr. **var. *anomalus***
In *Q. frainetto* forests, in groups, collected once in December 1999 (S1*). This taxon is a member of subgenus *Seriocybe*, section *Anomali* and the main diagnostic features were the blue-lilac or violet traces on pileus stipe and young lamellae, the whitish veil forming annular zones on stipe, and the subglobose spores (7.5-10 x 6.5-7.7 μm).

****Cortinarius balteatocumatilis*** Henry ex Orton
In *Q. frainetto* forests. in small groups, collected once in December 1999 (S1*). Typical of this taxon is the macrochemical reaction of flesh with KOH (yellow-brown with yellow at the edge), the peronate volvate stipe base, the violet cortina in young basidiomata and the habitat (oak forests). The similar-looking taxon *C. balteatus* (Fr.) Fr. is found in coniferous forests and lacks the violet colour from the veil (Breitenbach & Kränzlin 2000).

†***Cortinarius cinnabarinus*** Fr.
In *Q. frainetto* forests, in groups or small clusters, not common, collected once in December 1999 (S1*). One previous record in *F. sylvatica* (Dimou & al. 2002).

†***Cortinarius cotoneus*** Fr.
In *Q. frainetto* forests, solitary, rare, collected once in December 1999 (S1*). One previous report from *F. sylvatica* forests (Zervakis & al. 1998).

†***Cortinarius infractus*** Fr.
In *Q. frainetto* forests, solitary, relatively common, late November-December (S1*). Only two previous records from Greece, in conifer forests of Mt. Taygetos (Maire & Politis 1940, Zervakis & al., submitted).

****Cortinarius rufoolivaceus* var. *pallidus*** M.M. Moser
In *Q. frainetto* forests, rare, December 1999 (S1*). Typical features of this taxon are the copper or wine-red colour of pileus that fades to clay-pink or pale salmon at margin, the marginate bulbous wine-brown stipe base, and the strong reaction of flesh with KOH (turning immediately dark green and then slowly dark red-brown). The characteristic of this variety is the white grey-olivaceus stipe colour instead of the violaceus colour in *C. rufoolivaceus* (Pers.) Fr. (Breitenbach & Kränzlin 2000).

†***Cortinarius traganus*** (Weinm.) Fr.
In *Q. frainetto* forests, solitary or in small groups, rather uncommon, October-November (S1). Reported only twice in Greece from conifer forests (Diamandis 1992, Zervakis & al. 1998).

Cortinarius trivialis J.E. Lange
In *Q. frainetto* and in *Q. pubescens* forests, solitary or in small groups, rather common, October-November (S1, S1*, Chrysochori). Reported previously in Greece from oak (Diamandis 1992, Diamandis & Perlerou 1990) and beech forests (Dimou & al. 2002).

****Cortinarius variecolor* var. *marginatus*** M.M. Moser
In *Q. frainetto* forests, solitary or in small groups, rare, October-November 1996 (S1). This taxon belongs to the section *Coerulescentes*, subsection *Variecolores*, and presents stipe with edged bulbous base and violet-foxy pileus (Moser 1983).

†***Cystoderma amianthinum*** (Scop.) Fayod
In *Q. frainetto* forests, in groups, rather common, September-October (S1). Common in Greece, reported mainly from conifer forests.

†***Dacrymyces capitata*** Schw.
On fallen twigs of *Q. frainetto*, uncommon, October-November 1997 (Exochori). Only two previous reports from central Greece on *Abies* spp. (Minter 1988).

†***Daedalea quercina*** L.
On dead *Q. frainetto* wood, uncommon, January 1997 (Exochori) and May 1999 (Paradeisia). Only one previous report from central and northern Greece (Minter 1988).

†***Datronia mollis*** (Sommerf.) Donk
On rotten log of *J. regia*, uncommon, March 2000 (Agia Theodora). Only one previous report from central and northern Greece on *Tilia* sp. (Minter 1988).

†***Dichomitus campestris*** (Quél.) Domanski & Orlicz
On standing twigs and branches of *Q. coccifera*, November 1999 (Nedon gorge). Common in Greece on *Quercus* spp., however this is the first record on *Q . coccifera* (Zervakis & al. 1998).

†***Entoloma hirtipes*** (Schum.) M.M. Moser
In *Q. frainetto* forests, solitary, not common, collected only once in December 1999 (S1*). Rather common in Greece in various habitats, however this is the first record in a *Quercus* forest (Zervakis & al. 1998).

†***Entoloma rhodopolium* f. *nidorosum*** (Fr.) Noordel.
On soil or leaf litter in *Q. frainetto* forests, solitary or in small groups, collected once in November 1999 (S1*). One previous report as *E. nidorosum* (Fr.) Quél. in beech forests (Maire & Politis 1940).

†***Entoloma sinuatum*** (Bull.) P. Kummer
In *Q. frainetto* and in *Q. pubescens* forests, solitary or in small groups, uncommon, October-November 1996 (Megalopoli). Rather common in Greece in deciduous forests, but this is the first record in *Q. pubescens* (Zervakis & al. 1998).

****Exidia recisa*** (Ditmar.) Fr.
On fallen twigs of *Carpinus betulus*, uncommon, October-November 1997 (Exochori). A quite distinctive taxon, forms basidiomata irregularly plate-shaped to ear-lobed, slightly shiny, dark brown, with elastic, dry and tough flesh.

†***Exidia truncata*** Fr.
On fallen twigs and branches of *Q. frainetto*, common, October (S1*). One previous record on *Quercus* sp. (Dimou & al. 2001).

†***Fomes fomentarius*** (L.) J. J. Kickx
On dead wood of *Q. frainetto* and in *Q. pubescens*, uncommon on this host, October (S1*). Common in Greece on a variety of hosts.

†***Ganoderma lucidum*** (Curt.) P. Karst.
On *P. orientalis* and on *Q. frainetto*, rather common, October-November (S1*, S1). Common in Greece on various hosts (Zervakis & al. 1998); however, this is the first host record for *P. orientalis*.

†***Handkea utriformis*** (Bull.) Kreisel
In *Q. frainetto* forest meadow rich in manure, uncommon, September-October 1999 (S1*). Reported from various habitats in Greece as *Calvatia utriformis* (Bull.) Jaap, *C. bovista* (Pers.) Fr. and *Lycoperdon bovista* Linn. (Zervakis & al. 1998).

Hebeloma sinapizans (Paulet) Gill.
In *Q. frainetto* forests, in groups, rather common, October-November (S1, S1*). Common in Greece in a variety of habitats.

****Hydnellum concrescens*** (Pers.) Banker
In *Q. frainetto* forests, in groups, rare, November 1999 (S1*). Macroscopically similar to *H. scrobiculatum* (Fr.) P. Karst., but spore width is up to 4.5 µm and pileus surface is more distinctly zoned (Breitenbach & Kränzlin 1986).

†***Hydnellum scrobiculatum*** (Fr.) P. Karst.
On soil rich in humus in *Q. frainetto* forests, in groups, uncommon, October-November 1997 (Exochori). Only one previous report from Greece in *Alnus glutinosa* (Diamandis 1992).

Hydnum repandum L.
In *Q. pubescens* forests, solitary, rare, December 1999 (S1*). Common in Greece in various habitats.

†***Hygrocybe conica*** (Scop.) P. Kummer
In *Q. frainetto* and *Q. pubescens* forests, solitary or in small groups, common, October-November (Chrysochori, S1). Common in Greece.

****Hygrocybe miniata*** (Fr.) P. Kummer
In *Q. frainetto* forests, solitary, rare, collected once in December 1999 (S1*). Diagnostic features of this taxon were the scarlet to orange-red colours of basidiomata with minute concolourous scales on pileus surface, the pear-shaped spores (constricted or broadened at base) and the cylindric elements of lamellar trama measuring 40-120 (200) µm. In the similar taxon *H. helobia* (Arnolds) Bon, the lamellar trama consists of long fusoid elements usually longer than 200 µm and measuring up to 1,500 µm.

†***Hygrocybe persistens*** (Britz.) Britz.
On grassy soil in *Q. frainetto* forest, solitary, rare, collected once in November 1999 (S1*). Previously reported in Greece under different names (Zervakis & al. 1998).

†***Hygrophorus cossus*** (Sowerby) Fr.
On leaf litter and grass in *Q. pubescens* and in *Q. frainetto* forest clearings, rather common, October-November (Paradeisia-Ag. Apostoloi, S1*). Previously reported in central and northern Greece (Diamandis & Perlerou 1990, Athanasiou & Théochari 1999, Dimou & al. 2002); this is the first record in *Q. pubescens*.

†***Hygrophorus dichrous*** Kühner & Romagn.
Among shrubs in *Q. coccifera*, uncommon, November-December (Proastio). Only one previous report from Greece in *Q. frainetto* (Diamandis 1992).

†***Hygrophorus russula*** (Fr.) Quél.
In mixed forest of *Carpinus betulus* and *Q. pubescens*, uncommon, late October to November 1997 (Exochori). Reported a few times in deciduous forests of Greece (Zervakis & al. 1998).

****Hyphodontia pruni*** (Lasch) J. Erikss. & Hjortstam
On decorticated, rotten wood of *Q. frainetto*, October 2000 (S1*). This taxon is a member of *H. crustosa* group, from which it differs in smaller size of aculei, and broadly ellipsoid to subglobose basidiospores measuring 5-6.5 x 4-4.5 μm (ellipsoid, 6.0-7.5 x 2.5-3 μm in *H. quercina*).

†***Hyphodontia quercina*** (Pers.) J. Erikss.
On dead branches on standing *Q. frainetto* trees, uncommon, October-November 1997 (Exochori). Only two previous reports from northern Greece (Minter 1988, Kotlaba & Klan 1994).

Hypholoma fasciculare (Huds.) P. Kummer
On *Q. frainetto*, common, late September-November (S1). Common in Greece in a wide range of hosts.

†***Inocybe rimosa*** (Bull.) P. Kummer
In *Q. frainetto* and in *Q. pubescens* forests, solitary or in small groups, rather common, November-December (Proastio, Paradeisia). Rather common in Greece in hardwood forests, previously reported as *I. fastigiata* (Schaeff.) Quél..

†***Inocybe geophylla* var. *lilacina*** (Peck) Gill.
In *Q. frainetto* and in *Q. pubescens* forests, rather common, October-November (S1, Megalopoli). Common in Greece.

****Irpex lacteus*** (Fr.) Fr.
On dead *Q. frainetto* wood, rare, May 1999 (S1). The irpicoid–hydnoid hymenophore of mature basidiomata with spines up to 1 mm, the dimitic hyphal system, the generative hypha with simple septa, and the long thick-walled apically incrusted cystidia are diagnostic characters of this taxon (Ryvarden & Gilbertson 1993).

†***Junghuhnia nitida*** (Pers.) Ryvarden
On the underside of a dead piece of *Q. frainetto* wood, rare, May 1999 (Paradeisia). Only two previous records from Mt. Ossa on *F. sylvatica*, and Mt. Olympos on *Abies* sp. and *C. sativa* (Minter 1988).

†***Laccaria laccata*** (Scop.) Cooke
In *Q. frainetto* and in *Q. pubescens* forests, in groups, common, September-October (Chrysochori, Exochori, S1*). Common in Greece in a variety of habitats; however, this is the first record in *Q. frainetto*.

†***Laccaria proxima*** (Boud.) Pat.
On moss among shrubs in *Q. frainetto*, in groups, uncommon, September-October 1996 (S1). Only one previous report from Greece in Mt. Taygetos (Maire & Politis 1940).

Laccaria purpureobadia D.A. Reid
On moss among shrubs in *Q. frainetto*, forests in groups, rare, October 1996 (S1). This species is characterized by damp dark purple-brown and finely scaly small pileus, and dark purple-brown fibrous stipe (Moser 1983).

Lactarius deliciosus (L.) Gray
In *Q. frainetto* forests, solitary or in groups, rather common, October-December (S1). Common in Greece on various habitats.

Lactarius evosmus Kühn.
In mixed *Q. frainetto* and *Q. pubescens* forests, solitary, uncommon, October-November 1998 (Paradeisia). Pilei are large (10-13 cm), infundibuliform, buff to light yellow with dark zonations towards the margin, with dense lamellae and white latex with peppery taste (Moser 1983).

Lactarius tesquorum Malençon
On soil under *Cistus* sp. shrubs in a *Q. pubescens* forest, solitary, relatively common, December (S1*, Paradeisia). The short stipe (always smaller than 2.5-3 cm) and the existence of basidiomata close or under shrubs of the genus *Cistus* are typical for this characteristic member of the Mediterranean mycoflora. The similar taxon *L. mairei* Malençon bears basidiomata with longer stipe and broader spores (Ballero & al. 1992, Moser 1983). Only one previous record from Andros island (Polemis & al. 2001).

****Lactarius volemus* var. *oedematopus* (Fr.)** sensu M. M. Moser
In mixed forests of *Q. frainetto* and *Q. pubescens*, in small groups, uncommon, June 1999 (Karnasi-Ag. Anargyroi).

Lactarius zonarius (Bull.) Fr.
In mixed *Q. frainetto* and *Q. pubescens* forests, solitary, October-November (Paradeisia, Megalopoli), and in *Q. ilex* and *P. orientalis*, November (Nedon gorge). Two previous records from Greece in hardwood forests (Diamandis & Perlerou 1990, Zervakis & al. 1998)

†***Laetiporus sulphureus*** (Bull.) Murrill
On branches of living *Q. frainetto* trees high above the ground, uncommon on this host, September-October 1997 (S1). Common in Greece on various hardwoods.

†***Lepiota clypeolaria*** (Bull.) P. Kummer
In *Q. frainetto* forests, rather common, October (S1). Rather common in Greece, reported mainly from conifer forests.

†***Lepiota cristata*** (Fr.) P. Kummer
In *Q. frainetto* forests, common, September-October (S1). It should be considered as a rather common species in Greece.

****Lepiota fulvella*** Rea
In *Q. frainetto* forest, rare, October 1996 (S1). This species grows in damp habitats, it presents deep bright orange-brown and fibrous-scaly pileus, with whitish lamellae and stipe with the same colour as pileus below the ring zone.

****Lepiota ignivolvata*** Bousset & Joss.
On leaf litter of *Q. frainetto*, solitary to gregarious, not common, November 2000 (S1*). The distinctive features of this taxon are the reddening of the stipe base, the smooth dextrinoid spores (9.0-13.2 x 4.6-6.3 μm), and the relatively smooth to longitudinally white-fibrillose surface of the stipe above the annulus.

†***Lepista luscina*** (Fr.) Singer
In *Q. frainetto* forests, in groups, rather uncommon, December 1999 (S1*). Reported only once before in Greece in *P. brutia* (Diamandis & Perlerou 1990).

†***Lepista nuda*** (Bull.) Cooke
In *Q. frainetto* forests, December 1997 (S1*), and in *Q. coccifera*, December 1997 (Saïdona), solitary or in small groups, uncommon. Common in Greece, previously reported in a wide variety of habitats.

†***Lepista sordida*** (Fr.) Singer
In *Q. frainetto* forests, rather common, October-November (S1*). Common in Greece, previously reported in a wide variety of habitats.

****Leucoagaricus serena*** (Fr.) Bon & Boiffard
In grassy openning of *Q. frainetto* forest, solitary–subgregarious, not common, November 1999 (S1*). Basidiomata of this taxon are characterized by smooth hyaline, dextrinoid, not metachromatic, thick-walled spores lacking germ pore 6.2-9.0 x 4.0-5.2 μm. Pileipellis consists of thin, hyaline, periclinal hyphae and septa without clamps (Moser 1983, Breitenbach & Kränzlin 1995). Another species of this genus, *L. sericifer* (Locq.) Vellinga, was previously recorded outside of a mixed *Q. coccifera* and *Juniperus* sp. forest (Dimou & al., unpublished results).

****Leucopaxillus compactus*** (Fr.) Neuhoff
In mixed forest of *Q. frainetto* and *C. betulus*, uncommon, October-November (Exochori). This taxon presents tomentose to suede-like pileus, incurved and slightly ribbed margin, sulfur-yellow lamellae, a clavate stipe, and spores which are broadly elliptic and verrucose (5.1-7.2 x 3.3-4.8 μm).

†***Lycoperdon molle*** Pers.
In *Q. frainetto* forests, uncommon, October and December 1999 (S1, S1*). Only one previous report from northern Greece (Minter 1988).

†***Lycoperdon perlatum*** Pers.
In *Q. frainetto* forest clearings, in small groups, common, October-November (S1). Common in Greece in a wide variety of habitats; however, this is the first report from *Q. frainetto* forests (Zervakis & al. 1998).

†***Macrolepiota excoriata*** (Schaeff.) Wasser
In mixed forest of *Q. pubescens* and in *Q. frainetto*, rather common, November (Paradeisia). Rather common in Greece.

****Macrolepiota heimii*** (Locq.) Bon
In *Q. frainetto* and *Q. pubescens* mixed forest clearings among shrubs, in groups, uncommon, October-November (Paradeisia). Although this taxon looks morphologically similar to *Leucoagaricus* spp., it bears distinctly larger basidia (32-40 x 14-17 μm), and spores (12.1-15.7 x 7.8-9.2 μm), and it possesses clamps in the hymenium (Breitenbach & Kränzlin 1995).

****Macrolepiota konradii*** (Huijm.ex P.D. Orton) M.M. Moser
In *Q. frainetto* and *Q. pubescens* mixed forest clearings among shrubs, in groups, rather common, October-November (S1*, Paradeisia). Typical for this taxon is the following combination of features: Pileus with prominent dark brown membranous scales that form a star-shaped pattern around the umbo, stem with pale brown adder-pattern, the onion like bulbous stipe base and the size of spores (11-17 x 8-10 μm).

†***Macrolepiota mastoidea*** (Fr.) Singer
In *Q. frainetto* forest clearings, solitary, uncommon, September-October 1996 and 1997 (S1). Previously reported from a variety of habitats in Greece.

†***Macrolepiota procera*** (Scop.) Singer
In *Q. frainetto* forest clearings, in groups, uncommon, September-October 1996 and 1999 (S1, S1*). Common in Greece, previously reported from a variety of habitats but not from *Q. frainetto* (Zervakis & al. 1998).

†***Marasmius anomalus*** Lasch
On grass stems and roots in *Q. frainetto*, solitary or gregarious, uncommon, November (Dyrrachi). Only one previous record in Greece (Maire & Politis 1940).

†***Marasmius oreades*** (Bolt.) Fr.
On grassy meadow in *Q. frainetto* forest, abundant forming fairy-rings, late April-May and from September to November (S1*). Scarcely reported from Greece (Zervakis & al. 1998).

****Marasmius setosus*** (Sowerby) Noordel.
On petioles and veins of *Q. frainetto* leaves, solitary or gregarious, November 1999 (S1*). Basidiomata possessed a finely hairy-downy stipe, whitish at apex and reddish-brown to the base. Microscopically it is characterized by smooth cells in the pileipellis and fusiform subcapitate cheilocystidia. Clamp connections were observed in all tissues, except at the base of basidia. Spores size was measured to be 8-11 x 3.5-4.5 µm.

****Melanoleuca politoinaequalipes*** (Beguet) Bon
In a grassy opening of *Q. frainetto* forest, solitary, rare, November 1999 (S1*). This taxon is classified in the subgenus *Urticocystis*, section *Grammopodiae* and stirp *Excissa*, because of the cheilocystidia type. Our specimens possessed a characteristic dark sepia, glutinous (when moist) pileus up to 5cm in diam., and 2- and 4-spored basidia. All previous characters are identical to those provided by Watling & Turnbull (1998). Additionally a sweet-fruity odor was noted, a feature that is only referred to by Bon (1991).

†***Mycena arcangeliana*** Bres.
On rotten stump of *Q. frainetto*, solitary or in small clusters, late November-December (S1*). Three previous reports from *Fagus* forests in northern Greece as *M. oortiana* Kühn. ex Hora (Diamandis 1983, Avtzis & Diamandis 1988), and in central Greece (Dimou & al. 2002).

†***Mycena erubescens*** Höhn.
On the base of a *Q. frainetto* stump, in small clusters, late November-December (S1*). Previously recorded only in *A. cephalonica* (Pantidou 1980; Zervakis & al., submitted).

†***Mycena galopus*** (Pers.) P. Kummer
On leaves and twigs of *Q. frainetto* and *Q. pubescens*, in small clusters, rare, late November-December 1999 (S1*). Previously reported in Greece from coniferous and hardwood forests (Maire & Politis 1940, Diamandis 1985, Avtzis & Diamandis 1988).

Mycena inclinata (Fr.) Quél.
In *Q. frainetto* forest, rather common, October-November (S1). Reported only twice before from deciduous habitats (Diamadis 1983, Dimou & al. 2002), but probably not rare in Greece.

†***Mycena polygramma*** (Bull.) Gray
In the hollow part of a *Q. pubescens* stump, uncommon, October-November 1998 (Paradeisia). Rather common in Greece, reported from deciduous habitats.

†***Mycena pura*** (Pers.) P. Kummer
On leaf litter in *Q. frainetto* and in *Q. pubescens*, common, October-November (S1, S1*, Paradeisia). Common in Greece in a wide range of habitats.

Mycena rosea (Bull.) Gramberg
On leaf litter in *Q. frainetto*, rather common, October-November (S1, S1*, Paradeisia). Reported in *Q. frainetto* (Diamandis & Perlerou 1990), and in *Fagus orientalis* and *F. sylvatica* (Diamandis 1992, Dimou & al. 2002).

†***Omphalotus olearius*** (DC.) Singer
In *Q. frainetto* and *Q. coccifera* forests, solitary, rare in this particular habitat, October-November 1996 (Chrysochori). Common in Greece.

Panaeolus acuminatus (Schaeff.) Quél.
On soil in grassy meadow within a *Q. frainetto* forest, solitary, rare, November 1999 (S1*). Few previous records from Greece reported as *P. rickenii* Hora (Diamandis 1983, Diamandis 1992, Dimou & al. 2002).

Peniophora quercina (Fr.) Cooke
On dead *Q. frainetto* branches, rather common, May (S1*). Common in Greece on hardwood.

†***Phanerochaete velutina*** (Fr.) P. Karst.
On the bark of a *Q. frainetto* dead branch and on *P. orientalis*, uncommon, March 2000 (S1). Only one previous record from Greece on *Pinus radiata* (Diamandis 1992).

†***Phellinus ferruginosus*** (Schrad.) Pat.
On dead trunk of *Platanus* sp., uncommon, November 2000 (Isaris). Only one previous record from northwestern Greece on *Quercus* sp. (Kotlaba & Klan 1994).

†***Phellinus torulosus*** Pers.
On dead wood of *Q. frainetto*, uncommon, May (Paradeisia). Common in Greece on various hardwoods.

†***Pholiota cerifera*** (P. Karst.) P. Karst.
On *Q. frainetto* living trees and stumps, in clusters, uncommon, October-November 1998 (Paradeisia-Megalopoli). Common in Greece reported mostly on *Abies* spp. as *P. aurivella* (Fr.) P. Kummer, and on hardwood as *P. adiposa* (Fr.) P. Kummer (Zervakis & al. 1998).

†***Pisolithus arhizus*** (Scop.: Pers.) Rauschert
In clearings of *Q. frainetto* and *Q. pubescens* forests, solitary, abundant, October-November (Paradeisia). Although reported in Greece only twice in the past (Maire & Politis 1940, Polemis 1998), many specimens were recently recorded in areas of southern Peloponnese and in other regions in a wide variety of habitats (Zervakis & al., submitted; Dimou & al., unpublished data). However this constitutes the first record from oak forests.

Polyporus arcularius Batsch
On fallen twigs of *Q. frainetto*, rare, September-October 1996 and 1998 (S1). Rather common in Greece on various hardwoods.

†***Polyporus meridionalis*** (A. David) Jahn
On *Prunus* sp. fallen dead trees in a *Q. frainetto* forest, several basidiomata, uncommon, October 1997 and May 1999 (S1, S1*). This taxon has typically small pilei (up to 4 cm in diam.), large pores (ca. 1 mm) radially elongated and ellipsoid spores (7-10 x 3-4 μm). It is considered to be a Mediterranean species (Ryvarden & Gilbertson 1993). One previous report from *Q. coccifera* (Dimou & al. 2001).

****Psathyrella bipellis*** (Quél.) A.H. Sm.
On wood and leaves debris of *Q. frainetto*, in small clusters, rare, November 1999 (S1). Characteristic of this taxon is the dark purple-brown colour of pileus that fades to gray-pink when dry, the presence of veil on the pileus surface in young basidiomata and the ventricose cheilocystidia filled with fine drops at the apex (Breitenbach & Kränzlin 1995, van Waveren 1985).

Psathyrella candolleana (Fr.) Maire
On wood and leaf litter of *Q. frainetto*, rather common, October-November (S1*). Rather common, recorded in central and northern Greece from hardwood forests.

†***Psathyrella murcida*** (Fr.) Kits van Wav.
On humus and woody debris of *Q. frainetto*, solitary, rare, November 1999 (S1*). Pileus strongly hygrophanous, dark brown and striate when wet, ochre with slightly sulcate margin when dry, veil forming weakly visible fibrils only when very young, lamellae distant, spores 8-

10 x 4-6 µm, cheilocystidia lageniform with interspersed pyriform cells, and pleurocystidia fusito lageniform (van Waveren 1985). Previously recorded in *Fagus* forests (Dimou & al. 2002).

Psathyrella ochracea (Romagn.) Kits van Wav.
On woody debris in *Q. frainetto*, in small groups, uncommon, November 1999 and October 2000 (S1*). Diagnostic features of this taxon are the strongly radially wrinkled surface of pileus, the absence of veil in young basidiomata, the polymorphic cheilocystidia, and the large size of spores (12-15 x 6.5-7.3 µm) (van Waveren 1985).

Psathyrella phegophila Romagn.
In *Q. frainetto* forests, in small groups, uncommon, late September-October 1999 (S1*). This taxon is characterized by its relatively large basidiomata with subdistant lamellae, utriform pleurocystidia and very slight veil. It is closely related to *P. fusca* (Schum.) Pears. from which it differs at its lamellar edge being characteristically lined with large number of conspicuous pyriform-clavate cells intermixed with scattered utriform cheilocystidia (van Waveren 1985).

Psathyrella spadiceogrisea (Schaeff.) Maire
In *Q. frainetto* forests, solitary or gregarious among *Quercus* twigs, late September-November 1999 (S1*). Although this taxon is considered fruiting mainly in spring, our collections were made in autumn. Our specimens possessed characteristic features such as reddish-brown pileus fading primarily in the center and margin to light ochre, margin striate when wet and with few fugacious remnants of the veil (when very young). Microscopically it is characterized by utriform subcapitate–capitate pleurocystidia, and similar cheilocystidia intermixed with pyriform or clavate cells and spores 8-10(11) x 4.5-5.2 µm (van Waveren 1985).

†***Pseudoclitocybe cyathiformis*** (Bull.) Singer
In grassy meadow at the edge of *Q. frainetto* forest, solitary or in small groups, not common, November 1999 (S1*). Common in Greece in a variety of habitats.

†***Ramaria flaccida*** Bourd.
In *Q. coccifera* and other evergreen shrubs (Koskaraka), in *Q. pubescens* (S1*), solitary–gregarious, in rows, November–December. Only two previous records in a mixed *A. cephalonica* and *P. nigra* forest (Delivorias & Gonou-Zagou 2000), and in *A. cephalonica* and *Q. coccifera* forest (Zervakis & al., submitted).

†***Rhodocybe gemina*** (Fr.) Kuyper & Noordel.
In *Q. frainetto and Q. pubescens* forests, solitary or in small groups, uncommon, October-November 1997 (Megalopoli). One previous report from central Greece as *R. truncata* (Schaeff.) Singer (Minter 1988), and one from Mt. Taygetos (Zervakis & al., submitted).

†***Rhodocybe nitellina*** (Fr.) Singer
In *Q. frainetto* forest, solitary or in small groups, rare, October 1996 (S1). Only two records from Greece in conifers (Pantidou 1980; Zervakis & al., submitted).

†***Russula albonigra*** (Krombh.) Fr.
In *Q. frainetto* forests, solitary, rare, September-October 1996 (S1). Only one previous record from Greece in *Castanea* sp. (Maire & Politis 1940).

Russula barlae Quél.
In *Q. frainetto* forests, solitary, rare, October 1996 (S1). It is characterized by the orange to copper-coloured pileus, cream spore-print, and the warty, slightly reticulate spores (7.0-8.9 x 6.1-7.8 µm).

†***Russula chloroides*** Krombh.
In *Q. coccifera* forest, gregarious, common, October-November (Nedon gorge), and in mixed forests of *Q. frainetto* and *Q. pubescens*, solitary or in groups, abundant, June 1999 (Veligosti, Karnasi). Only one previous record from Greece (Zervakis & al. 1998).

†***Russula delica*** Fr.
In *Q. frainetto* and *Q. pubescens* mixed forests, solitary or in small groups, common, October-November (Megalopoli, Chrysochori, Paradeisia). Common in Greece in various habitats.

†***Russula rosea*** Pers.
In *Q. frainetto* and *Q. pubescens* mixed forests, solitary, rare, October-November 1996 (Megalopoli).

****Russula vinosobrunnea*** (Bres.) Romagn.
In *Q. frainetto* and *Q. pubescens* mixed forests, solitary or in small groups, uncommon, October-November 1997 (Megalopoli-Paradeisia). It bears purplish-black to purple-brown pileus with an olivaceus centre, spiny-ridged spores measuring 7.6-9.8 x 6.4-8.1 μm, and presents deep-ochre spore-print.

†***Schizopora paradoxa*** (Schrad.) Donk
On dead wood of *Q. frainetto*, uncommon, May 2000 (Paradeisia). Few previous reports from Greece.

†***Scleroderma bovista*** Fr.
In clearings of *Q. frainetto* forests, solitary, uncommon, November (S1). Only two previous reports from Greece (Heufler 1868, Diamandis 1992).

Stereum gausapatum (Fr.) Fr.
On *Q. frainetto*, rather common, all-year (S1*), Rather common in Greece on hardwoods.

Stereum hirsutum (Wild.) Gray
On *Q. frainetto*, common, all-year (S1, S1*, Paradeisia). Common and widespread in Greece on hardwoods.

Stereum ochraceoflavum (Schw.) Ellis
On *Q. frainetto*, uncommon, all-year (S1). Only two previous reports from Greece (Minter 1988, Diamandis 1992).

†***Stropharia aeruginosa*** (Curt.) Quél.
On humus and wood debris in *Q. frainetto* forest, solitary or in small groups, common, October-November (S1). Common in Greece in a wide range of habitats.

†***Stropharia coronilla*** (Bull.) Quél.
In *Q. frainetto* forest clearing, solitary, rather common, October-November (S1). Scarcely reported from Greece until now (Zervakis & al. 1998).

†***Stropharia squamosa*** (Pers.) Quél.
In *Q. frainetto* and *Platanus orientalis* stands, in small groups, uncommon, October-November 1997 (S1). Reported only twice in the past in *F. sylvatica* (Diamandis 1985, Zervakis & al. 1998).

Terana caerulea (Law.) Kuntze
On dead wood of *Q. frainetto*, rather common, October-November (Exochori, Paradeisia). Rather common in Greece recorded on various hardwoods as *Pulcherricium caeruleum* (Fr.) Parmasto.

†***Trametes hirsuta*** (Wulf.) Quél.
On stumps of *Q. frainetto*, common, all-year (S1). Common in Greece.

****Trametes ljubarskii*** Pilát
On dead trunk of *P. orientalis*, solitary, sessile, rare, October 2000 (Isaris). The almost smooth glabrous, azonate, ochraceus upper surface of pileus in mature basidiomata, as well as the size of pores (3-4 per mm) and spores (5-6.3 x 3-3.6 μm) are typical for this taxon that is known mainly from the Mediterranean area (Ryvarden & Gilbertson 1993).

†***Trametes versicolor*** (L.) Pilát
On fallen branches and stumps of *Q. frainetto* and *Q. pubescens*, common, all-year (S1, S1*, Megalopoli). Common throughout Greece in a wide range of hosts (Zervakis & al. 1998); however, *Q. frainetto* is a new host record.

†***Trechispora farinacea*** (Pers.) Liberta
On rotten wood of *Q. frainetto*, rare, March 2000 (S1). Reported only once in the past in Greece from hardwoods (Minter 1988).

†***Tremella foliacea*** Pers.
On rotten stump of *Q. frainetto*, solitary, not common, collected only once in November 2000 (S1*). Few previous reports from Greece on *Q. ilex, Q. pubescens* and *C. sativa* (Zervakis & al. 1998).

Tremella mesenterica Fr.
On *Q. frainetto* forest, solitary, common, December (S1*). Rather common in Greece.

†***Tricholoma acerbum*** (Bull.) Quél.
In *Q. frainetto* forest, rather common, in small groups, late September-November (S1). Reported only once before from Greece in *C. sativa* (Pantidou & Gonou 1984).

Tricholoma atrosquamosum (Chev.) Sacc.
In *Q. frainetto* forests, common, in small groups, October-November (S1). Common in Greece.

†***Tricholoma scalpturatum*** Fr.: Quél.
In *Q. frainetto* forests, rather rare, in small groups, October-November 1996 (S1). Only one previous record in *A. cephalonica* from the same region (Zervakis & al., submitted).

†***Vascellum pratense*** (Pers.) Kreisel
In *Q. frainetto* and *Q. pubescens* forest meadows rich in manure, September-November (S1*). Common in pasturelands or associated with conifers.

Volvariella gloiocephala (DC.) Singer
On humus in *Q. frainetto* forest clearings, common, October-November (S1, S1*). Common in Greece.

Vuilleminia comedens (Nees) Maire
On *Q. frainetto*, rare, December 1999 (S1*). Reported only twice in the past from central and northern Greece on hardwoods (Minter 1988, Diamandis 1992).

*****Vuilleminia cystidiata*** Parmasto
On branches of *Crataegus monogyna*, rare, December 1999 (S1*). The presence of subulate cystidia on hymenial surface and the host-preference for species of Rocaceae are the main distinguishing characters from *V. comedens* (Nees) Maire (Hjortstam & al. 1988).

*****Xenasma pruinosum*** (Pat.) Donk
On the underside of a rotten *J. regia* log, rare, March 2000 (Agia Theodora). Typical features of this taxon are the pleural basidia with 4-6 sterigmata (10-20 x 6-9 μm), the long cylindric cystidia (40-100 x 5-10 μm), the cylindric-capitate and septate cystidioles (20-60 x 3-6 μm), and the inamyloid spores (6-8 x 3-4 μm) finely verrucose with warts soluble in KOH. Only one previous record of a *Xenasma* species in Greece, i.e. *X. pulverulentum* (Litsch.) Donk (Dimou & al., unpublished results).

†***Xerocomus badius*** (Fr.) Gill.
In *Q. frainetto* forests, in small groups, rare, September 1999 (S1*). Only one previous record in *Pinus* sp. (Pantidou 1973).

†***Xerocomus chrysenteron*** (Bull.) Quél.
In *Q. frainetto* and in *Q. pubescens* forests, solitary or in small groups, common, September-October (S1, S1*, Paradeisia). Common in Greece in a large variety of habitats (Zervakis & al. 1998); however, this is the first report from *Q. pubescens*.

†***Xerocomus rubellus*** (Krombh.) M.M. Moser
In *Q. frainetto* forests, solitary or in small groups, uncommon, late September-October 1999 (S1*, Paradeisia). Three previous reports from Greece (Maire & Politis 1940, Pantidou 1973, Diamandis 1992).

†***Xerocomus subtomentosus*** (L.) Quél.
In *Q. frainetto* and *Q. pubescens* forests, solitary, uncommon, October 1996 and 1998 (S1, Paradeisia). Common in Greece.

DISCUSSION

The number and percentages of fungal species growing as mycorrhizal, biotrophic, saprotrophic on humus and saprotrophic on woody species was calculated as follows: 65 (32.7%), 5 (2.5%), 77 (38.7%) and 52 (26.1%) respectively; these ratios could be indicative of the ecological status of the biotopes under study (Fellner 1993).

The succession of the most common genera (or species) of macrofungi were as previously reported for the macrofungi of Mt. Taygetos (Zervakis et al., submitted); while the richest period in macrofungi diversity was from October to November followed by December to early January for Basidiomycotina, and late autumn for larger Ascomycotina.

Consumption of wild mushrooms is exercised in a very limited manner for edible species such as *Boletus edulis*, *Macrolepiota procera*, *Lactarius deliciosus*, *Cantharellus cibarius*, etc., and only by a few inhabitants of the neighbouring villages. However, the main problems for the conservation of fungal biodiversity in the area under study are grazing, forest fires and illegal privatization of forest areas. Hence, appropriate legislation needs to be enforced (in some cases also to be established) to avoid hazards associated with anthropogenic activities.

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MYCOTAXON

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AN INDEX TO KUMMER'S DER FÜHRER IN DIE PILZKUNDE, 1871

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ABSTRACT

The taxa described in Paul Kummer's *Der Führer in die Pilzkunde* are fully indexed, and supplied with their authorities (consistently lacking in Kummer's text). All specific and varietal entries are cross-referenced to previous, major European mycological publications with which, presumably, Kummer would have been acquainted. A separate, annotated, nomenclatural listing supplies citations, basionyms, and earlier nomenclatural synonyms of the 593 new names published in Kummer's book; these include 2 gen. nov., 6 sp. nov., 1 var. nov., and 18 nom. nov., as well as 566 new combinations of earlier names (including 21 Friesian *Agaricus* infrageneric taxa raised to generic rank).

KEYWORDS: nomenclature, systematics, Agaricales, macrofungi

"Es sei hierbei bemerkt, daß ich die große Gruppe der Blätterpilze . . . , welche von den meisten Autoren als die einige große Gattung *Agaricus* aufgeführt werden, aus guten Gründen in viele Gattungen zerlegt, ihnen aber meist die Namen gegeben habe, mit denen man herkömmlich die Gattung *Agaricus* zu gruppiren pflegte." Paul Kummer, *Führer Pilzk.*: 12, 1871.

INTRODUCTION

Paul Kummer, 1834–1912, was a German clergyman and lichenologist who lived and worked initially in his birthplace, Zerbst (Sachsen-Anhalt), and later in Hann. Münden (Niedersachsen) (Urban 1935; Stafleu & Cowan 1979). In 1871, he published a field guide to the macrofungi found in central Germany, *Der Führer in die Pilzkunde* (Kummer 1871), a work of little taxonomic significance but of immense importance for mycological nomenclature. In its day, the book was sufficiently popular to warrant publication of a second edition expanded to include microfungi (Kummer 1881, 1884), but it appears to have been largely ignored by mycologists; indeed the first edition does not even rate a mention in Lindau & Sydow's *Thesaurus* (1908).

Almost 80 years were to elapse before Kummer was rescued from obscurity, when Donk (1949a) documented his role as the author who first raised many of the *Agaricus* infrageneric taxa of Elias Fries to generic rank — a role that was slightly diminished, but otherwise unaffected, by Donk's (1949b) subsequent discovery that six of the taxa had already been raised to generic rank by Staude (1857). Donk's findings initially resulted in a storm of controversy (Rogers 1950; Singer 1951, 1955; Donk 1954, 1962), but have since been accepted into mycological orthodoxy.

The nomenclatural contribution of Kummer's *Der Führer in die Pilzkunde* includes: (a) elevation to generic rank of 21 Friesian *Agaricus* infrageneric taxa — *Camarophyllus*, *Clitopilus*, *Coprinarius*, *Eccilia*, *Entoloma*, *Flammula*, *Galera*, *Hebeloma*, *Hygrocybe*, *Hypholoma*, *Leptonia*, *Limacium*, *Myxacium*, *Naucoria*, *Nolanea*, *Pholiota*, *Pleurotus*, *Psalliota*, *Psathyra*, *Psilocybe*, and *Volvaria*; (b) publication of numerous new combinations (plus a few new taxa) in each of these 21 new genera and another 12 agaric genera — *Amanita*, *Armillaria*, *Clitocybe*, *Collybia*, *Crepidotus*, *Galorrheus*, *Inocybe*, *Lepiota*, *Mycena*, *Omphalia*, *Pluteus*, and *Tricholoma*; and (c) publication of a small number of new combinations in each of the agaric genera *Coprinus*, *Cortinarius*, *Gomphus* (sensu Weinm., non Pers.), *Marasmius*, and *Russula*, and the non-agaric genera *Daedalea*, *Irpex*, *Polyporus*, and *Thelephora*. However, Kummer's numerous specific and varietal recombinations have been incorporated into the literature only on a piecemeal basis over the past 50 years, and a large proportion of his names continue to be attributed incorrectly to later authors, particularly his French contemporaries Quélet (1872-75) and Gillet (1874–78).

The original 1871 edition of Kummer's *Der Führer in die Pilzkunde* is not held widely in mycological libraries. Moreover, even where a copy is available, the contents of the book remain difficult to access. Its format is a pocket-sized 20 × 13 cm, and the print is in dense paragraphs of Blackletter Gothic type. The bulk of the book consists of a key to genera (*Tabelle zum Bestimmen der Gattungen*, pp. 13–26) and keys to species (*Tabellen zum Bestimmen der Arten*, pp. 27–138). In the species keys, the Latin binomials (with abbreviated generic names) are not easily discernible. They are embedded within the German text, usually at the end of a paragraph but occasionally in the middle, and are not set off by any typographic device other than being printed in Roman type. Some infraspecific taxa are characterised explicitly as "var.", others imprecisely as "Abart" (= variety (Spielart), subspecies (Unterart), or strain, fide Springer 1974, p. 2). No authorities or basionyms are cited anywhere in the text. In Kummer's epithet index (*Lateinische Artennamen*, pp. 140–145), many specific epithets are missing and varietal epithets are almost totally absent, many listed epithets are misspelt or widely misplaced in the alphabetic sequence, and many page references are incorrect. To add to the difficulty, no generic placements are indicated in the index, and all adjectival epithets are cited in the masculine gender only; this can be baffling for those whose Latin is rudimentary — for example, *Myxacium elegantius* is represented in the index as "*elegantior*"!

The purpose of this paper is twofold: (a) to catalogue the full corpus of Kummer's nomenclatural contribution (see NOMENCLATURAL NOVELTIES IN KUMMER'S *DER FÜHRER IN DIE PILZKUNDE*, below); and (b) to provide a complete and accessible index to his book (see INDEX TO KUMMER'S *DER FÜHRER IN DIE PILZKUNDE*, below).

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Stafleu, F.A.; Cowan, R.S. 1979. Taxonomic literature, vol. 2. Utrecht. 991 p.

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NOMENCLATURAL NOVELTIES IN KUMMER'S *DER FÜHRER IN DIE PILZKUNDE*

The 593 new names published in Kummer's book are listed, with their citations, basionyms, and other nomenclatural synonyms published before 1871. Nine entries are designated as new taxa, first described in Kummer's book; four of these (*Leucopus* gen. nov., *Rhaphanozon* gen. nov., *Russula narcotica*, sp. nov., and *Collybia erythropus* var. *citrinella* var. nov.) are explicitly new, whereas the other five (*Cortinarius cuprarius*, *Flammula saniosa*, *Hebeloma pallidum*, *Inocybe avellana*, and *Tricholoma urens*) are assumed to be sp. nov. because no synonymous earlier use of these epithets has been located. *Thelephora florida* may also be a sp. nov., but an alternative possibility is that the name is a lapsus calami for *Thelephora floriformis* comb. nov. Eighteen entries are designated as nom. nov., but only one of these (*Myxacium ochroleucum*) involves the publication of a substitute epithet; the other 17 retain the epithets of their illegitimate "basionyms" (cf. ICBN (St Louis Code) Article 58). Taxa that Kummer characterised as "Abart" have been interpreted as varieties.

Amanita excelsa (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 138, 1871.
  ≡ *Agaricus excelsus* Fr.:Fr. 1821.
Amanita rieckei (Rabenh.) P.Kumm., *Führer Pilzk.*: 138, 1871, as "*rieckii*".
  ≡ *Agaricus rieckei* Rabenh. 1840.
Amanita secretanii (Rabenh.) P.Kumm., *Führer Pilzk.*: 137, 1871, as "*secretani*".
  ≡ *Agaricus secretanii* Rabenh. 1844.
Amanita secretanii var. *guttata* (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 137, 1871.
  ≡ *Agaricus guttatus* Pers.:Fr. 1793.
  ≡ *Agaricus secretanii* c. *guttatus* (Pers.:Fr.) Rabenh. 1844.
Amanita secretanii var. *lenticularis* (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 137, 1871, as "*lenticularia*".
  ≡ *Agaricus lenticularis* Lasch:Fr. 1828.
  ≡ *Agaricus secretanii* b. *lenticularis* (Pers.:Fr.) Rabenh. 1844.
Amanita spissa (Fr.) P.Kumm., *Führer Pilzk.*: 138, 1871.
  ≡ *Agaricus spissus* Fr. 1838.
Armillaria aurantia (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 134, 1871.
  ≡ *Agaricus aurantius* Schaeff.:Fr. 1774.
Armillaria bulbigera (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 135, 1871.
  ≡ *Agaricus bulbiger* Alb. & Schwein.:Fr. 1805.
Armillaria denigrata (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 135, 1871.
  ≡ *Agaricus denigratus* Pers.:Fr. 1801.
Armillaria laschii (Fr.) P.Kumm., *Führer Pilzk.*: 135, 1871.
  ≡ *Agaricus laschii* Fr. 1838.
Armillaria mellea (Vahl:Fr.) P.Kumm., *Führer Pilzk.*: 134, 1871.
  ≡ *Agaricus melleus* Vahl:Fr. 1790.
Armillaria mucida (Schrad.:Fr.) P.Kumm., *Führer Pilzk.*: 135, 1871.
  ≡ *Agaricus mucidus* Schrad.:Fr. 1794.
Armillaria ramentacea (Bull. ex Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 134, 1871.
  ≡ *Agaricus ramentaceus* Bull. ex Pers.:Fr. 1801.

Armillaria robusta (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 135, 1871.
≡ *Agaricus robustus* Alb. & Schwein.:Fr. 1805.
Armillaria straminea P.Kumm., *Führer Pilzk.*: 134, 1871, nom. nov.
≡ *Agaricus stramineus* Krombh. 1836, nom. illegit., non Scop. 1772.
Camarophyllus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 26, 1871.
≡ *Agaricus* trib. *Clitocybe* subtrib. *Camarophylli* Fr.:Fr. 1821.
≡ *Hygrophorus* trib. *Camarophyllus* (Fr.:Fr.) Fr. 1838.
Camarophyllus caprinus (Scop.) P.Kumm., *Führer Pilzk.*: 118, 1871.
≡ *Agaricus caprinus* Scop. 1772.
≡ *Hygrophorus caprinus* (Scop.) Fr. 1838.
Camarophyllus irrigatus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 118, 1871.
≡ *Agaricus irrigatus* Pers.:Fr. 1801.
≡ *Hygrophorus irrigatus* (Pers.:Fr.) Fr. 1838.
Camarophyllus nemoreus (Fr.) P.Kumm., *Führer Pilzk.*: 118, 1871.
≡ *Agaricus nemoreus* Lasch 1828, nom. illegit., non Pers.:Fr. 1801.
≡ *Hygrophorus nemoreus* Fr. 1838, nom. nov.
Camarophyllus ovinus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 118, 1871.
≡ *Agaricus ovinus* Bull.:Fr. 1793.
≡ *Hygrophorus ovinus* (Bull.:Fr.) Fr. 1838.
Camarophyllus pratensis (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 118, 1871.
≡ *Agaricus pratensis* Pers.:Fr. 1800.
≡ *Hygrophorus pratensis* (Pers.:Fr.) Fr. 1838.
Camarophyllus virgineus (Wulfen:Fr.) P.Kumm., *Führer Pilzk.*: 117, 1871.
≡ *Agaricus virgineus* Wulfen:Fr. 1781.
≡ *Hygrophorus virgineus* (Wulfen:Fr.) Fr. 1838.
Camarophyllus virgineus var. *niveus* (Fr.) P.Kumm., *Führer Pilzk.*: 117, 1871, as "*nivea*".
≡ *Agaricus niveus* Scop. 1772, nom. illegit., non Pers.:Fr. 1801.
≡ *Hygrophorus niveus* Fr. 1838, nom. nov.
≡ *Agaricus virgineus* b. *niveus* (Fr.) Rabenh. 1844.
Clitocybe adhaerens (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 121, 1871.
≡ *Agaricus adhaerens* Alb. & Schwein.:Fr. 1805.
Clitocybe amara (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 121, 1871.
≡ *Agaricus rivulosus* ββ *amarus* Alb. & Schwein.:Fr. 1805.
≡ *Agaricus amarus* (Alb. & Schwein.:Fr.) Fr. 1821.
Clitocybe amethystina (Bolton) P.Kumm., *Führer Pilzk.*: 122, 1871, sub *Clitocybe laccata*.
≡ *Agaricus amethystinus* Bolton 1788.
Clitocybe ampla (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 120, 1871.
≡ *Agaricus amplus* Pers.:Fr. 1801.
Clitocybe angustissima (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871.
≡ *Agaricus angustissimus* Lasch:Fr. 1829.
Clitocybe bella (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 123, 1871.
≡ *Agaricus bellus* Pers.:Fr. 1801.
Clitocybe candicans (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871.
≡ *Agaricus candicans* Pers.:Fr. 1801.
Clitocybe cerussata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871.
≡ *Agaricus cerussatus* Fr.:Fr. 1821.
Clitocybe chrysoleuca (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871, as "*crysoleuca*".
≡ *Agaricus chrysoleucus* Fr.:Fr. 1815, non Pers. 1801.
Clitocybe clavipes (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 124, 1871.
≡ *Agaricus clavipes* Pers.:Fr. 1801.
Clitocybe cochleata (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871.
≡ *Agaricus cochleatus* Pers.:Fr. 1793.
Clitocybe comitialis (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 124, 1871.
≡ *Agaricus comitialis* Pers.:Fr. 1801.
Clitocybe cyathiformis (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 120, 1871, as "*cyathiformus*".
≡ *Agaricus cyathiformis* Bull.:Fr. 1785–86.
Clitocybe dealbata (Sowerby:Fr.) P.Kumm., *Führer Pilzk.*: 121, 1871.
≡ *Agaricus dealbatus* Sowerby:Fr. 1799.

Clitocybe dealbata var. *rivulosa* (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871, as "Abart".
≡ *Agaricus rivulosus* Pers.:Fr. 1801.

Clitocybe decastes (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 124, 1871.
≡ *Agaricus decastes* Fr.:Fr. 1818.

Clitocybe diatreta (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 121, 1871.
≡ *Agaricus diatretus* Fr.:Fr. 1818.

Clitocybe expallens (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 120, 1871.
≡ *Agaricus expallens* Pers.:Fr. 1801.

Clitocybe flaccida (Sowerby:Fr.) P.Kumm., *Führer Pilzk.*: 124, 1871.
≡ *Agaricus flaccidus* Sowerby:Fr. 1799.

Clitocybe fragrans (Sowerby:Fr.) P.Kumm., *Führer Pilzk.*: 121, 1871.
≡ *Agaricus fragrans* Sowerby:Fr. 1797.

Clitocybe fumosa (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 124, 1871.
≡ *Agaricus fumosus* Pers.:Fr. 1801.

Clitocybe gibba (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 123, 1871.
≡ *Agaricus gibbus* Pers.:Fr. 1801.

Clitocybe gibba var. *fuliginea* (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 120, 1871, as "Abart".
≡ *Agaricus gibbus* ββ *fuligineus* Alb. & Schwein.:Fr. 1805.

Clitocybe gilva (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 124, 1871.
≡ *Agaricus gilvus* Pers.:Fr. 1801.

Clitocybe gilva var. *geotropa* (Bull. ex DC.) P.Kumm., *Führer Pilzk.*: 124, 1871, as "*geotropus*", "Abart".
≡ *Agaricus geotropus* Bull. ex DC. 1805.
≡ *Agaricus gilvus* c. *geotropus* (Bull. ex DC.) Rabenh. 1844.

Clitocybe gilva var. *splendens* (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 124, 1871, as "Abart".
≡ *Agaricus splendens* Pers.:Fr. 1801.
≡ *Agaricus gilvus* b. *splendens* (Pers.:Fr.) Rabenh. 1844.

Clitocybe hirneola (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 120, 1871.
≡ *Agaricus hirneolus* Fr.:Fr. 1818.

Clitocybe hoffmannii P.Kumm., *Führer Pilzk.*: 123, 1871, as "*hoffmanni*", nom. nov. sed superfl.
≡ *Agaricus cervinus* Hoffm.:Fr. 1789.
≡ *Agaricus hoffmannii* Rabenh. 1844, nom. nov. sed illegit., non Pers. 1828.

Clitocybe hydrogramma (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871.
≡ *Agaricus hydrogrammus* Bull.:Fr. 1792.

Clitocybe laccata (Scop.:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871, as "*lauata*".
≡ *Agaricus laccatus* Scop.:Fr. 1772.

Clitocybe lepidea (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 123, 1871.
≡ *Agaricus lepideus* Fr.:Fr. 1821.

Clitocybe maxima (P.Gaertn., B.Mey. & Scherb.:Fr.) P.Kumm., *Führer Pilzk.*: 123, 1871.
≡ *Agaricus maximus* P.Gaertn., B.Mey. & Scherb.:Fr. 1802.
≡ *Agaricus gibbus* γ *maximus* (P.Gaertn., B.Mey. & Scherb.:Fr.) Fr. 1828.

Clitocybe metachroa (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 120, 1871, as "*metachrous*".
≡ *Agaricus metachrous* Fr.:Fr. 1821.

Clitocybe molybdina (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 120, 1871.
≡ *Agaricus molybdinus* Fr.:Fr. 1821.

Clitocybe muscorum (Hoffm.:Fr.) P.Kumm., *Führer Pilzk.*: 123, 1871.
≡ *Agaricus muscorum* Hoffm.:Fr. 1789.

Clitocybe nebularis (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 124, 1871.
≡ *Agaricus nebularis* Batsch:Fr. 1789.

Clitocybe obolus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 120, 1871.
≡ *Agaricus obolus* Fr.:Fr. 1821.

Clitocybe odora (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 121, 1871.
≡ *Agaricus odorus* Bull.:Fr. 1791.

Clitocybe opipara (Fr.) P.Kumm., *Führer Pilzk.*: 121, 1871.
≡ *Agaricus opiparus* Fr. 1838.

Clitocybe phyllophila (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871.
≡ *Agaricus phyllophilus* Pers.:Fr. 1801.

Clitocybe pruinosa (Lasch) P.Kumm., *Führer Pilzk.*: 120, 1871.
≡ *Agaricus pruinosus* Lasch 1838.
Clitocybe rubella (Schaeff.) P.Kumm., *Führer Pilzk.*: 122, 1871, sub *Clitocybe laccata*.
≡ *Agaricus rubellus* Schaeff. 1774.
Clitocybe sinopica (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 123, 1871.
≡ *Agaricus sinopicus* Fr.:Fr. 1818.
Clitocybe solida (Lasch) P.Kumm., *Führer Pilzk.*: 124, 1871.
≡ *Agaricus solidus* Lasch 1829.
Clitocybe squamulosa (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 123, 1871.
≡ *Agaricus squamulosus* Pers.:Fr. 1801.
Clitocybe suaveolens (Schumach.:Fr.) P.Kumm., *Führer Pilzk.*: 121, 1871.
≡ *Agaricus suaveolens* Schumach.:Fr. 1803.
Clitocybe subalutacea (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 124, 1871.
≡ *Agaricus subalutaceus* Batsch:Fr. 1789.
Clitocybe tigrina (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 121, 1871, as "*Clitocybe (Omphalia) figrina*".
≡ *Agaricus tigrinus* Bull.:Fr. 1781–82.
Clitocybe tornata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 122, 1871.
≡ *Agaricus tornatus* Fr.:Fr. 1821.
Clitocybe umbilicata P.Kumm., *Führer Pilzk.*: 123, 1871, as "*ambilicata*", nom. nov.
≡ *Agaricus umbilicatus* Schaeff. 1774, nom. illegit., non Scop. 1772.
Clitopilus (Fr. ex Rabenh.) P.Kumm., *Führer Pilzk.*: 23, 1871.
≡ *Agaricus* trib. *Mouceron* Fr.:Fr. 1821.
≡ *Agaricus* trib. *Clitopilus* Fr. 1838, nom. nov. sed illegit., non Fr.:Fr. 1821.
≡ *Agaricus* subgen. *Clitopilus* Fr. ex Rabenh. 1844.
Clitopilus angustus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 97, 1871.
≡ *Agaricus angustus* Pers.:Fr. 1801.
Clitopilus cicatrisatus (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 97, 1871.
≡ *Agaricus cicatrisatus* Lasch:Fr. 1828.
Clitopilus mundulus (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 97, 1871.
≡ *Agaricus mundulus* Lasch:Fr. 1829.
Clitopilus neglectus (Lasch) P.Kumm., *Führer Pilzk.*: 97, 1871.
≡ *Agaricus neglectus* Lasch 1828.
Clitopilus orcella (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 97, 1871.
≡ *Agaricus orcella* Bull.:Fr. 1793.
Clitopilus popinalis (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 97, 1871.
≡ *Agaricus popinalis* Fr.:Fr. 1821.
Clitopilus prunulus (Scop.:Fr.) P.Kumm., *Führer Pilzk.*: 97, 1871.
≡ *Agaricus prunulus* Scop.:Fr. 1772.
Collybia acervata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus acervatus* Fr.:Fr. 1821.
Collybia anthracophila (Lasch) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus anthracophilus* Lasch 1829.
Collybia aquosa (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus aquosus* Bull.:Fr. 1780–81.
Collybia asema (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 117, 1871.
≡ *Agaricus butyraceus γ asemus* Fr.:Fr. 1818.
≡ *Agaricus asemus* (Fr.:Fr.) Fr. 1821.
Collybia atrata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus atratus* Fr.:Fr. 1818.
Collybia butyracea (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 117, 1871.
≡ *Agaricus butyraceus* Bull.:Fr. 1792.
Collybia clavus (L.:Fr.) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus clavus* L.:Fr. 1753.
Collybia collina (Scop.:Fr.) P.Kumm., *Führer Pilzk.*: 115, 1871.
≡ *Agaricus collinus* Scop.:Fr. 1722.
Collybia confluens (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 117, 1871.
≡ *Agaricus confluens* Pers.:Fr. 1796.

Collybia conigena (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 116, 1871, as "*conigenus*".
≡ *Agaricus conigenus* Pers.:Fr. 1801.
Collybia crassipes (Schaeff.) P.Kumm., *Führer Pilzk.*: 117, 1871, as "*crassipes (fusipes)*".
≡ *Agaricus crassipes* Schaeff. 1774.
Collybia dryophila (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 115, 1871.
≡ *Agaricus dryophilus* Bull..:Fr. 1790.
Collybia erythropus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 115, 1871.
≡ *Agaricus erythropus* Pers.:Fr. 1801.
Collybia erythropus var. *citrinella* P.Kumm., *Führer Pilzk.*: 115, 1871, var. nov.
Collybia esculenta (Wulfen:Fr.) P.Kumm., *Führer Pilzk.*: 115, 1871.
≡ *Agaricus esculentus* Wulfen:Fr. 1781.
Collybia fuscopurpurea (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 116, 1871.
≡ *Agaricus fuscopurpureus* Pers.:Fr. 1798.
Collybia longipes (Bull.) P.Kumm., *Führer Pilzk.*: 117, 1871.
≡ *Agaricus longipes* Bull. 1785.
Collybia maculata (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 117, 1871.
≡ *Agaricus maculatus* Alb. & Schwein.:Fr. 1805.
Collybia murina (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus murinus* Batsch:Fr. 1783.
Collybia muscigena (Schumach.:Fr.) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus muscigenus* Schumach.:Fr. 1803.
Collybia ocellata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus ocellatus* Fr.:Fr. 1815.
Collybia oreades (Bolton:Fr.) P.Kumm., *Führer Pilzk.*: 116, 1871.
≡ *Agaricus oreades* Bolton:Fr. 1792.
Collybia peronata (Bolton:Fr.) P.Kumm., *Führer Pilzk.*: 116, 1871.
≡ *Agaricus peronatus* Bolton:Fr. 1788.
Collybia planca (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 116, 1871, as "*plancus*".
≡ *Agaricus plancus* Fr.:Fr. 1821.
Collybia platyphylla (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 117, 1871.
≡ *Agaricus platyphyllus* Pers.:Fr. 1796.
Collybia plexipes (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus plexipes* Fr.:Fr. 1821.
Collybia porrea (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 115, 1871.
≡ *Agaricus porreus* Fr.:Fr. 1818.
Collybia radicata (Relhan:Fr.) P.Kumm., *Führer Pilzk.*: 117, 1871, as "*radicans*".
≡ *Agaricus radicatus* Relhan:Fr. 1786.
Collybia stolonifera (Jungh.) P.Kumm., *Führer Pilzk.*: 115, 1871.
≡ *Agaricus stolonifer* Jungh. 1830.
Collybia tenacella (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 114, 1871.
≡ *Agaricus tenacellus* Pers.:Fr. 1794.
Collybia tuberosa (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 116, 1871.
≡ *Agaricus tuberosus* Bull.:Fr. 1785–86.
Collybia urens (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 115, 1871.
≡ *Agaricus urens* Bull.:Fr. 1791.
Collybia velutipes (Curtis:Fr.) P.Kumm., *Führer Pilzk.*: 116, 1871.
≡ *Agaricus velutipes* Curtis:Fr. 1782.
Coprinarius (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 20, 1871, nom. rej. [≡ *Panaeolus* (Fr.) Quél.]
≡ *Agaricus* trib. *Coprinarius* Fr.:Fr. 1821.
Coprinarius acuminatus (Schaeff.) P.Kumm., *Führer Pilzk.*: 69, 1871.
≡ *Agaricus acuminatus* Schaeff. 1774.
Coprinarius callosus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 69, 1871.
≡ *Agaricus callosus* Fr.:Fr. 1818.
Coprinarius campanulatus P.Kumm., *Führer Pilzk.*: 69, 1871, nom. nov.
≡ *Agaricus campanulatus* L. 1755, nom. illegit., non L. 1753, nec Bull.:Fr. 1792.
Coprinarius compactus (Schumach.:Fr.) P.Kumm., *Führer Pilzk.*: 69, 1871.
≡ *Agaricus compactus* Schumach.:Fr. 1803.

Coprinarius conocephalus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus conocephalus* Bull.:Fr. 1792–93.
Coprinarius corrugis (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 69, 1871.
≡ *Agaricus corrugis* Pers.:Fr. 1794.
Coprinarius crenatus (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus crenatus* Lasch:Fr. 1828.
Coprinarius disseminatus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus disseminatus* Pers.:Fr. 1800.
Coprinarius ericaeus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 69, 1871.
≡ *Agaricus ericaeus* Pers.:Fr. 1801.
Coprinarius fimicola (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 69, 1871.
≡ *Agaricus fimicola* Fr.:Fr. 1821.
Coprinarius fimiputris (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus fimiputris* Bull.:Fr. 1781–82.
Coprinarius gracilis (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus gracilis* Fr.:Fr. 1821.
Coprinarius hydrophorus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus hydrophorus* Bull.:Fr. 1792–93.
Coprinarius papilionaceus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus papilionaceus* Bull.:Fr. 1781–82.
Coprinarius papyraceus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus papyraceus* Pers.:Fr. 1801.
Coprinarius subliquescens (Schumach.:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus subliquescens* Schumach.:Fr. 1803.
Coprinarius subtilis (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 68, 1871.
≡ *Agaricus subtilis* Fr.:Fr. 1821.
Coprinarius udus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 69, 1871.
≡ *Agaricus udus* Pers.:Fr. 1801.
Cortinarius umbrinus (Pers.) P.Kumm., *Führer Pilzk.*: 88, 1871, as "*umbrinus (torvus)*".
≡ *Agaricus umbrinus* Pers. 1801, p. 280.
[non *Cortinarius umbrinus* M.M.Moser 1975, nom. illegit.]
Coprinus digitaliformis (Bull.) P.Kumm., *Führer Pilzk.*: 66, 1871.
≡ *Agaricus digitaliformis* Bull. 1780–81.
Cortinarius cuprarius P.Kumm., *Führer Pilzk.*: 86, 1871, sp. nov.
Cortinarius eumorphus (Pers.) P.Kumm., *Führer Pilzk.*: 90, 1871.
≡ *Agaricus eumorphus* Pers. 1801.
Cortinarius notatus (Pers.) P.Kumm., *Führer Pilzk.*: 87, 1871.
≡ *Agaricus notatus* Pers. 1801.
Crepidotus alveolus (Lasch) P.Kumm., *Führer Pilzk.*: 74, 1871.
≡ *Agaricus alveolus* Lasch 1829.
Crepidotus applanatus (Pers.) P.Kumm., *Führer Pilzk.*: 74, 1871.
≡ *Agaricus applanatus* Pers. 1796.
Crepidotus byssisedus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 74, 1871.
≡ *Agaricus byssisedus* Pers.:Fr. 1800.
Crepidotus depluens (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 74, 1871.
≡ *Agaricus depluens* Batsch:Fr. 1786.
Crepidotus haustellaris (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 74, 1871.
≡ *Agaricus haustellaris* Fr.:Fr. 1818.
Crepidotus pezizoides (Nees & T.Nees:Fr.) P.Kumm., *Führer Pilzk.*: 74, 1871.
≡ *Agaricus pezizoides* Nees & T.Nees:Fr. 1818.
Crepidotus proboscideus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 74, 1871.
≡ *Agaricus proboscideus* Fr.:Fr. 1818.
Crepidotus variabilis (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 74, 1871.
≡ *Agaricus variabilis* Pers.:Fr. 1800.
Crepidotus violaceofulvens (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 74, 1871, as "*violaceofulvus*".
≡ *Agaricus violaceofulvens* Batsch:Fr. 1783.

Daedalea communis (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 53, 1871, as "*Daedalea (Schizophyllum) commune*". ≡ *Schizophyllum commune* Fr.:Fr. 1815.

Eccilia (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 23, 1871.
≡ *Agaricus* trib. *Eccilia* Fr.:Fr. 1821.

Eccilia atrides (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 94, 1871.
≡ *Agaricus atrides* Lasch:Fr. 1829.

Eccilia atropunctus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 94, 1871, as "*atropunctata*".
≡ *Agaricus atropunctus* Pers.:Fr. 1801.

Eccilia calophylla (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 94, 1871.
≡ *Agaricus calophyllus* Pers.:Fr. 1801.

Eccilia cyanula (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 94, 1871.
≡ *Agaricus cyanulus* Lasch:Fr. 1829.

Eccilia griseorubella (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 94, 1871.
≡ *Agaricus griseorubellus* Lasch:Fr. 1829.

Eccilia polita (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 95, 1871.
≡ *Agaricus politus* Pers.:Fr. 1801.

Eccilia rhodocylix (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 95, 1871.
≡ *Agaricus rhodocylix* Lasch:Fr. 1829.

Entoloma (Fr.) P.Kumm., *Führer Pilzk.*: 23, 1871.
≡ *Agaricus* trib. *Entoloma* Fr. 1838.

Entoloma argyropus (Alb. & Schwein.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus caesius* ββ *argyropus* Alb. & Schwein. 1805.
≡ *Agaricus argyropus* (Alb. & Schwein.) Rabenh. 1844.

Entoloma camelinum (Lasch) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus sinuatus* β *camelinus* Lasch 1829.

Entoloma clypeatum (L.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus clypeatus* L. 1753.

Entoloma costatum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus pascuus* β *costatus* Fr.:Fr. 1821.
≡ *Agaricus costatus* (Fr.:Fr.) Secr. 1833.

Entoloma dichroum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 97, 1871, as "*dichrous*".
≡ *Agaricus dichrous* Pers.:Fr. 1801.

Entoloma elodes (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus elodes* Fr.:Fr. 1821.

Entoloma griseocyaneum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 97, 1871.
≡ *Agaricus griseocyaneus* Fr.:Fr. 1821.

Entoloma rhodopolium (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus rhodopolius* Fr.:Fr. 1818.

Entoloma sericellum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 97, 1871.
≡ *Agaricus sericeus* β *sericellus* Fr.:Fr. 1818.
≡ *Agarius sericellus* (Fr.:Fr.) Fr. 1821.

Entoloma sinuatum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus sinuatus* Pers.:Fr. 1801.

Flammula (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 22, 1871.
≡ *Agaricus* trib. *Flammula* Fr.:Fr. 1821.

Flammula alnicola (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus alnicola* Fr.:Fr. 1821.

Flammula astragalina (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus astragalinus* Fr.:Fr. 1821.

Flammula carbonaria (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus carbonarius* Fr.:Fr. 1818.

Flammula cinnamomea (L.:Fr.) P.Kumm., *Führer Pilzk.*: 81, 1871.
≡ *Agaricus cinnamomeus* L.:Fr. 1753.

Flammula cinnamomea var. *conformis* (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 81, 1871, as "Abart".
≡ *Agaricus cinnamomeus* c. *conformis* Fr.:Fr. 1821.

Flammula cinnamomea var. *crocea* (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 81, 1871, as "Abart".
≡ *Agaricus croceus* Schaeff.:Fr. 1774.
≡ *Agaricus cinnamomeus* d. *croceus* (Schaeff.:Fr.) Fr. 1821.
Flammula cinnamomea var. *luteola* (Rabenh.) P.Kumm., *Führer Pilzk.*: 81, 1871, as "Abart".
≡ *Agaricus cinnamomeus* e. *luteolus* Rabenh. 1844.
Flammula cinnamomea var. *rubicunda* (Rabenh.) P.Kumm., *Führer Pilzk.*: 81, 1871, as "Abart".
≡ *Agaricus cinnamomeus* b. *rubicundus* Rabenh. 1844.
Flammula cinnamomea var. *semisanguinea* (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 81, 1871, as "Abart".
≡ *Agaricus cinnamomeus* a. *semisanguineus* Fr.:Fr. 1821.
Flammula flavida (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus flavidus* Schaeff.:Fr. 1774.
Flammula fusa (Batsch) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus fusus* Batsch 1789.
Flammula gummosa (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus gummosus* Lasch:Fr. 1828.
Flammula lenta (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus lentus* Pers.:Fr. 1801.
Flammula limonia (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 81, 1871.
≡ *Agaricus limonius* Fr.:Fr. 1818.
Flammula liquiritiae (Pers.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus liquiritiae* Pers. 1801.
Flammula lubrica (Pers.Fr.) P.Kumm., *Führer Pilzk.*: 81, 1871.
≡ *Agaricus lubricus* Pers.:Fr. 1801.
Flammula picrea (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus picreus* Pers.:Fr. 1798.
Flammula saniosa P.Kumm., *Führer Pilzk.*: 81, 1871, sp. nov.
[?= *Cortinarius saniosus* sensu P.Kumm., non Fr., fide E.Horak (pers. comm.)]
Flammula sapinea (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus sapineus* Fr.:Fr. 1821.
Flammula spumosa (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 81, 1871.
≡ *Agaricus spumosus* Fr.:Fr. 1821.
Flammula strigiceps (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus strigiceps* Fr.:Fr. 1821.
Flammula tricholoma (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 82, 1871.
≡ *Agaricus tricholoma* Alb. & Schwein.:Fr. 1805.
Galera (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 21, 1871, nom. illegit., non Blume 1825.
≡ *Agaricus* trib. *Galera* Fr.:Fr. 1821.
Galera conferta (Bolton:Fr.) P.Kumm., *Führer Pilzk.*: 76, 1871.
≡ *Agaricus confertus* Bolton:Fr. 1788.
Galera hypnorum (Schrank:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus hypnorum* Schrank:Fr. 1789.
Galera hypnorum var. *bryorum* (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus hypnorum* β *bryophilus* Pers. 1801.
≡ *Agaricus hypnorum* β *bryorum* Fr.:Fr. 1821, nom. nov.
Galera hypnorum var. *mniophila* (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871, as "*mniophilus*".
≡ *Agaricus mniophilus* Lasch:Fr. 1828.
≡ *Agaricus hypnorum* c. *mniophilus* (Lasch:Fr.) Rabenh. 1844.
Galera hypnorum var. *rubiginosa* (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871, as "*rubiginosus*".
≡ *Agaricus rubiginosus* Pers.:Fr. 1801.
≡ *Agaricus hypnorum* ε *rubiginosus* (Pers.:Fr.) Fr. 1821.
Galera hypnorum var. *sphagnorum* (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus hypnorum* γ *sphagnorum* Pers.:Fr. 1801.
Galera lateritia (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 76, 1871.
≡ *Agaricus lateritius* Fr.:Fr. 1821.
Galera leucophylla (Rabenh.) P.Kumm., *Führer Pilzk.*: 76, 1871.
≡ *Agaricus leucophyllus* Rabenh. 1844.

Galera paludosa (Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus paludosus* Fr. 1838.
Galera pellucida (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus pellucidus* Bull.:Fr. 1792.
Galera pityria (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 76, 1871, as "*pityrea*".
≡ *Agaricus pityrius* Fr.:Fr. 1821.
Galera reticulata (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 76, 1871.
≡ *Agaricus reticulatus* Pers.:Fr. 1798.
Galera spartea (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus sparteus* Fr.:Fr. 1821.
Galera spicula (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus spiculus* Lasch:Fr. 1829.
Galera stagnina (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus stagninus* Fr.:Fr. 1821.
Galera tenera (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus tener* Schaeff.:Fr. 1774.
Galera tenera var. *pilosella* (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871.
≡ *Agaricus pilosellus* Pers.:Fr. 1801.
≡ *Agaricus tener* β *pilosellus* (Pers.:Fr.) Fr. 1821.
Galera tenera var. *siliginea* (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871, as "*salignea*".
≡ *Agaricus siligineus* Fr.:Fr. 1818.
≡ *Agaricus tener* δ *siligineus* (Fr.:Fr.) Fr. 1821.
Galera vittiformis (Fr.) P.Kumm., *Führer Pilzk.*: 75, 1871, as "*vittaeformis*".
≡ *Agaricus vittiformis* Fr. 1838.
Galorrheus acris (Bolton:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Agaricus acris* Bolton:Fr. 1790.
≡ *Lactarius acris* (Bolton:Fr.) Gray 1821.
Galorrheus aurantiacus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Agaricus testaceus* γ *aurantiacus* Pers.:Fr. 1801.
≡ *Agaricus aurantiacus* (Pers.:Fr.) Fr. 1821, nom. illegit., non Wulfen:Fr. 1781.
Galorrheus blennius (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 127, 1871.
≡ *Agaricus blennius* Fr.:Fr. 1815.
≡ *Lactarius blennius* (Fr.:Fr.) Fr. 1838.
Galorrheus camphoratus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 127, 1871.
≡ *Agaricus camphoratus* Bull.:Fr. 1792–93.
≡ *Lactarius camphoratus* (Bull.:Fr.) Fr. 1838.
Galorrheus chloroides (Krombh.) P.Kumm., *Führer Pilzk.*: 128, 1871.
≡ *Agaricus chloroides* Krombh. 1843.
Galorrheus chrysorrheus (Fr.) P.Kumm., *Führer Pilzk.*: 127, 1871.
≡ *Lactarius chrysorrheus* Fr. 1838.
Galorrheus cilicioides (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 125, 1871.
≡ *Agaricus cilicioides* Fr.:Fr. 1821.
≡ *Lactarius cilicioides* (Fr.:Fr.) Fr. 1838.
Galorrheus controversus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 125, 1871.
≡ *Lactarius controversus* Pers.:Fr. 1800.
≡ *Agaricus controversus* (Pers.:Fr.) Pers. 1801.
Galorrheus crampylus (J.Otto:Fr.) P.Kumm., *Führer Pilzk.*: 125, 1871.
≡ *Agaricus crampylus* J.Otto:Fr. 1816.
≡ *Lactarius crampylus* (J.Otto:Fr.) Fr. 1838.
Galorrheus deliciosus (L.:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Agaricus deliciosus* L.:Fr. 1763.
≡ *Lactarius deliciosus* (L.:Fr.) Gray 1821.
Galorrheus flexuosus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 128, 1871.
≡ *Agaricus flexuosus* Pers.:Fr. 1801.
≡ *Lactarius flexuosus* (Pers.:Fr.) Gray 1821.
Galorrheus fuliginosus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 127, 1871.
≡ *Agaricus fuliginosus* Fr.:Fr. 1821.
≡ *Lactarius fuliginosus* (Fr.:Fr.) Fr. 1838.

Galorrheus glyciosmus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 129, 1871.
≡ *Agaricus glyciosmus* Fr.:Fr. 1818.
≡ *Lactarius glyciosmus* (Fr.:Fr.) Fr. 1838.

Galorrheus helvus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 129, 1871.
≡ *Agaricus helvus* Fr.:Fr. 1821.
≡ *Lactarius helvus* (Fr.:Fr.) Fr. 1838.

Galorrheus ichoratus (Batsch) P.Kumm., *Führer Pilzk.*: 128, 1871.
≡ *Agaricus ichoratus* Batsch 1786.
≡ *Lactarius ichoratus* (Batsch) Fr. 1838.

Galorrheus insulsus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Agaricus insulsus* Fr.:Fr. 1821.
≡ *Lactarius insulsus* (Fr.:Fr.) Fr. 1838.

Galorrheus jecorinus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Agaricus jecorinus* Fr.:Fr. 1821.
≡ *Lactarius jecorinus* (Fr.:Fr.) Fr. 1838.

Galorrheus listeri (Sowerby) P.Kumm., *Führer Pilzk.*: 128, 1871.
≡ *Agaricus listeri* Sowerby 1797.

Galorrheus luridus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871, as "*luvidus*".
≡ *Agaricus luridus* Pers.:Fr. 1801.
≡ *Lactarius luridus* (Pers.:Fr.) Gray 1821.

Galorrheus mitissimus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 128, 1871.
≡ *Agaricus mitissimus* Fr.:Fr. 1821.
≡ *Lactarius mitissimus* (Fr.:Fr.) Fr. 1838.

Galorrheus pallidus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Lactarius pallidus* Pers.:Fr. 1797.
≡ *Agaricus pallidus* (Pers.:Fr.) Pers. 1801.

Galorrheus pergamenus (Sw.:Fr.) P.Kumm., *Führer Pilzk.*: 128, 1871.
≡ *Agaricus pergamenus* Sw.:Fr. 1809.
≡ *Lactarius pergamenus* (Sw.:Fr.) Fr. 1838.

Galorrheus persoonii P.Kumm., *Führer Pilzk.*: 128, 1871, nom. nov.
≡ *Agaricus persoonii* J.Otto 1816, nom. illegit., non Fr.:Fr. 1818.

Galorrheus piperatus (Scop.:Fr.) P.Kumm., *Führer Pilzk.*: 128, 1871.
≡ *Agaricus piperatus* Scop.:Fr. 1772.
≡ *Lactarius piperatus* (Scop.:Fr.) Pers. 1797.

Galorrheus plumbeus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 129, 1871.
≡ *Agaricus lactifluus* var. *plumbeus* Bull.:Fr. 1786.
≡ *Agaricus plumbeus* (Bull.:Fr.) Bull. 1792–93.
≡ *Lactarius plumbeus* (Bull.:Fr.) Gray 1821.

Galorrheus pyrogalus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 127, 1871.
≡ *Agaricus pyrogalus* Bull.:Fr. 1792.
≡ *Lactarius pyrogalus* (Bull.:Fr.) Fr. 1838.

Galorrheus quietus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Agaricus quietus* Fr.:Fr. 1821.
≡ *Lactarius quietus* (Fr.:Fr.) Fr. 1838.

Galorrheus resimus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 125, 1871.
≡ *Agaricus resimus* Fr.:Fr. 1821.
≡ *Lactarius resimus* (Fr.:Fr.) Fr. 1838.

Galorrheus rubellus (Krombh.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Agaricus rubellus* Krombh. 1843.

Galorrheus rufus (Scop.:Fr.) P.Kumm., *Führer Pilzk.*: 129, 1871.
≡ *Agaricus rufus* Scop.:Fr. 1772.
≡ *Lactarius rufus* (Scop.:Fr.) Fr. 1838.

Galorrheus scrobiculatus (Scop.:Fr.) P.Kumm., *Führer Pilzk.*: 125, 1871.
≡ *Agaricus scrobiculatus* Scop.:Fr. 1772.
≡ *Lactarius scrobiculatus* (Scop.:Fr.) Fr. 1838.

Galorrheus serifluus (DC.:Fr.) P.Kumm., *Führer Pilzk.*: 128, 1871.
≡ *Agaricus serifluus* DC.:Fr. 1815.
≡ *Lactarius serifluus* (DC.:Fr.) Fr. 1838.

Galorrheus subdulcis (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 129, 1871.
≡ *Agaricus subdulcis* Pers.:Fr. 1801.
≡ *Lactarius subdulcis* (Pers.:Fr.) Gray 1821.

Galorrheus theiogalus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 127, 1871, as "*thejogalus*".
≡ *Agaricus theiogalus* Bull.:Fr. 1792–93.
≡ *Lactarius theiogalus* (Bull.:Fr.) Gray 1821.

Galorrheus tithymalinus (Scop.:Fr.) P.Kumm., *Führer Pilzk.*: 129, 1871.
≡ *Agaricus tithymalinus* Scop.:Fr. 1772.
≡ *Lactarius tithymalinus* (Scop.:Fr.) Fr. 1838.

Galorrheus tomentosus (J.Otto) P.Kumm., *Führer Pilzk.*: 125, 1871.
≡ *Agaricus tomentosus* J.Otto 1816.

Galorrheus torminosus (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 125, 1871.
≡ *Agaricus torminosus* Schaeff.:Fr. 1774.
≡ *Lactarius torminosus* (Schaeff.:Fr.)Gray 1821.

Galorrheus trivialis (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 127, 1871.
≡ *Agaricus trivialis* Fr.:Fr. 1815.
≡ *Lactarius trivialis* (Fr.:Fr.) Fr. 1838.

Galorrheus turpis (Weinm.) P.Kumm., *Führer Pilzk.*: 125, 1871.
≡ *Agaricus turpis* Weinm. 1826.
≡ *Lactarius turpis* (Weinm.) Fr. 1838.

Galorrheus umbrinus (Pers.) P.Kumm., *Führer Pilzk.*: 129, 1871.
≡ *Agaricus umbrinus* Pers. 1801, p. 435.
≡ *Lactarius umbrinus* (Pers.) Fr. 1838.

Galorrheus uvidus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Agaricus uvidus* Fr.:Fr. 1818.
≡ *Lactarius uvidus* (Fr.:Fr.) Fr. 1838.

Galorrheus vellereus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 125, 1871, as "*vellerea*".
≡ *Agaricus vellereus* Fr.:Fr. 1821.
≡ *Lactarius vellereus* (Fr.:Fr.) Fr. 1838.

Galorrheus vellereus var. *exsuccus* (Pers:Fr.) P.Kumm., *Führer Pilzk.*: 125, 1871 as "*exsulla*".
≡ *Lactarius piperatus* β *exsuccus* Pers.:Fr. 1800.
≡ *Agaricus piperatus* β *exsuccus* (Pers.:Fr.) Pers. 1801.
≡ *Agaricus exsuccus* (Pers.:Fr.) J.Otto 1816.
≡ *Agaricus vellereus* β *exsuccus* (Pers.:Fr.) Fr. 1821.

Galorrheus vietus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 126, 1871.
≡ *Agaricus vietus* Fr.:Fr. 1821.
≡ *Lactarius vietus* (Fr.:Fr.) Fr. 1838.

Galorrheus violascens (J.Otto:Fr.) P.Kumm., *Führer Pilzk.*: 127, 1871.
≡ *Agaricus violascens* J.Otto:Fr. 1816.
≡ *Lactarius violascens* (J.Otto:Fr.) Fr. 1838.

Galorrheus volemus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 127, 1871.
≡ *Agaricus volemus* Fr.:Fr. 1821.
≡ *Lactarius volemus* (Fr.:Fr.) Fr. 1838.

Galorrheus zonarius (Bull.) P.Kumm., *Führer Pilzk.*: 127, 1871.
≡ *Agaricus lactifluus* var. *zonarius* Bull. 1782–83.
≡ *Agaricus zonarius* (Bull.) Bull. 1792–93.
≡ *Lactarius zonarius* (Bull.) Fr. 1838.

Gomphus glutinosus (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871, nom. inval.
≡ *Agaricus glutinosus* Schaeff.:Fr. 1774.
≡ *Gomphidius glutinosus* (Schaeff.:Fr.) Fr. 1838.

Gomphus glutinosus var. *roseus* (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871, as "Abart", nom. inval.
≡ *Agaricus glutinosus* β *roseus* Fr.:Fr. 1821.
≡ *Gomphidius glutinosus* * *roseus* (Fr.:Fr.) Fr. 1838.

Gomphus viscidus (L.) P.Kumm., *Führer Pilzk.*: 93, 1871, nom. inval.
≡ *Agaricus viscidus* L. 1753.
≡ *Gomphidius viscidus* (L.) Fr. 1838.

Hebeloma (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 22, 1871.
≡ *Agaricus* trib. *Hebeloma* Fr.:Fr. 1821.

Hebeloma fastibile (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 80, 1871.
≡ *Agaricus fastibilis* Pers.:Fr. 1801.
Hebeloma longicaudum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 80, 1871.
≡ *Agaricus longicaudus* Pers.:Fr. 1801.
Hebeloma lugens (Jungh.:Fr.) P.Kumm., *Führer Pilzk.*: 80, 1871.
≡ *Agaricus lugens* Jungh.:Fr. 1830.
Hebeloma pallidum P.Kumm., *Führer Pilzk.*: 80, 1871, sp. nov.
[non *Hebeloma pallidum* Malençon 1970, nom. illegit.]
Hebeloma petiginosum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 80, 1871.
≡ *Agaricus petiginosus* Fr.:Fr. 1821.
Hebeloma punctatum (Fr..:Fr.) P.Kumm., *Führer Pilzk.*: 80, 1871.
≡ *Agaricus punctatus* Fr.:Fr. 1828.
Hebeloma truncatum (Schaeff.) P.Kumm., *Führer Pilzk.*: 80, 1871.
≡ *Agaricus truncatus* Schaeff. 1774.
Hygrocybe (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 26, 1871.
≡ *Agaricus* trib. *Clitocybe* subtrib. *Hygrocybi* Fr.:Fr. 1821.
≡ *Hygrophorus* trib. *Hygrocybe* (Fr.:Fr.) Fr. 1838.
Hygrocybe ceracea (Wulfen:Fr.) P.Kumm., *Führer Pilzk.*: 112, 1871.
≡ *Agaricus ceraceus* Wulfen:Fr. 1781.
≡ *Hygrophorus ceraceus* (Wulfen:Fr.) Fr. 1838.
Hygrocybe coccinea (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 112, 1871.
≡ *Agaricus coccineus* Schaeff.:Fr. 1774.
≡ *Hygrophorus coccineus* (Schaeff.:Fr.) Fr. 1838.
Hygrocybe conica (Scop.:Fr.) P.Kumm., *Führer Pilzk.*: 111, 1871.
≡ *Agaricus conicus* Scop.:Fr. 1772.
≡ *Hygrophorus conicus* (Scop.:Fr.) Fr. 1838.
Hygrocybe fragilis (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 112, 1871.
≡ *Agaricus fragilis* Batsch:Fr. 1789.
Hygrocybe laeta (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 112, 1871.
≡ *Agaricus laetus* Pers.:Fr. 1800.
≡ *Hygrophorus laetus* (Pers.:Fr.) Fr. 1838.
Hygrocybe miniata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 112, 1871.
≡ *Agaricus miniatus* Fr.:Fr. 1821.
≡ *Hygrophorus miniatus* (Fr.:Fr.) Fr. 1838.
Hygrocybe murinacea (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 112, 1871.
≡ *Agaricus murinaceus* Bull.:Fr. 1791.
≡ *Hygrophorus murinaceus* (Bull.:Fr.) Fr. 1838.
Hygrocybe psittacina (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 112, 1871.
≡ *Agaricus psittacinus* Schaeff.:Fr. 1774.
≡ *Hygrophorus psittacinus* (Schaeff.:Fr.) Fr. 1838.
Hygrocybe punicea (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 112, 1871.
≡ *Agaricus puniceus* Fr.:Fr. 1821.
≡ *Hygrophorus puniceus* (Fr.:Fr.) Fr. 1838.
Hygrocybe squalida (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 112, 1871.
≡ *Agaricus squalidus* Lasch:Fr. 1828.
≡ *Hygrophorus squalidus* (Lasch:Fr.) Fr. 1838.
Hypholoma (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 21, 1871, nom. cons.
≡ *Agaricus* trib. *Hypholoma* Fr.:Fr. 1821.
Hypholoma capnoides (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 72, 1871.
≡ *Agaricus capnoides* Fr.:Fr. 1818.
Hypholoma fasciculare (Huds.:Fr.) P.Kumm., *Führer Pilzk.*: 72, 1871 as "*fascicularis*".
≡ *Agaricus fascicularis* Huds.:Fr. 1778.
Hypholoma lateritium (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 72, 1871.
≡ *Agaricus lateritius* Schaeff.:Fr. 1774.
Hypholoma velutinum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 72, 1871.
≡ *Agaricus velutinus* Pers.:Fr. 1801.
≡ *Agaricus lacrymabundus* β *velutinus* (Pers.:Fr.) Fr. 1821.

Inocybe avellana P.Kumm., *Führer Pilzk.*: 79, 1871, sp. nov.
[non *Inocybe avellanea* Kobayasi 1952, nom. illegit.]
Inocybe carpta (Scop.) P.Kumm., *Führer Pilzk.*: 79, 1871.
≡ *Agaricus carptus* Scop. 1772.
Inocybe dulcamara P.Kumm., *Führer Pilzk.*: 79, 1871, nom. nov.
≡ *Agaricus dulcamarus* Alb. & Schwein. 1805, nom. illegit., non Pers. 1801.
Inocybe geophylla (Sowerby:Fr.) P.Kumm., *Führer Pilzk.*: 78, 1871, as "*geophyllus*".
≡ *Agaricus geophyllus* Sowerby:Fr. 1799.
Inocybe geophylla var. *sambucina* (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 78, 1871, as "Abart".
≡ *Agaricus sambucinus* Fr.:Fr. 1821.
Inocybe lacera (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 79, 1871.
≡ *Agaricus lacerus* Fr.:Fr. 1821.
Inocybe lacera var. *obscura* P.Kumm., *Führer Pilzk.*: 79, 1871, as "Abart", nom. nov.
≡ *Agaricus obscurus* Pers. 1801, nom. illegit., non Schaeff. 1774.
Inocybe lanuginosa (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 80, 1871.
≡ *Agaricus lanuginosus* Bull.:Fr. 1788.
Inocybe lucifuga (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 79, 1871.
≡ *Agaricus lucifugus* Fr.:Fr. 1818.
Inocybe pyriodora (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 79, 1871.
≡ *Agaricus pyriodorus* Pers.:Fr. 1801.
Inocybe repanda (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 78, 1871.
≡ *Agaricus repandus* Bull.:Fr. 1789.
Inocybe rimosa (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 78, 1871.
≡ *Agaricus rimosus* Bull.:Fr. 1789.
Inocybe scabella (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 79, 1871.
≡ *Agaricus scabellus* Alb. & Schwein.:Fr. 1805.
Inocybe scabra (O.F.Müll.:Fr.) P.Kumm., *Führer Pilzk.*: 79, 1871.
≡ *Agaricus scaber* O.F.Müll.:Fr. 1780.
Irpex confluens (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 49, 1871, as "*Irpex (Sistotrema)*".
≡ *Sistotrema confluens* Pers.:Fr. 1794.
Lepiota acutesquamosa (Weinm.:Fr.) P.Kumm., *Führer Pilzk.*: 136, 1871.
≡ *Agaricus acutesquamosus* Weinm.:Fr. 1822.
Lepiota cepistipes (Sowerby:Fr.) P.Kumm., *Führer Pilzk.*: 136, 1871, as "*cepaestipes*".
≡ *Agaricus cepistipes* Sowerby:Fr. 1797.
Lepiota clypeolaria (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 137, 1871.
≡ *Agaricus clypeolarius* Bull.:Fr. 1789.
Lepiota colubrina P.Kumm., *Führer Pilzk.*: 136, 1871, nom. nov. sed illegit., non Gray 1821.
≡ *Agaricus colubrinus* Krombh. 1831, nom. illegit., non Bull. 1781-82.
Lepiota cristata (Bolton:Fr.) P.Kumm., *Führer Pilzk.*: 137, 1871.
≡ *Agaricus cristatus* Bolton:Fr. 1788.
Lepiota delicata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 136, 1871.
≡ *Agaricus delicatus* Fr.:Fr. 1821.
Lepiota erminea (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 136, 1871.
≡ *Agaricus ermineus* Fr.:Fr. 1821.
Lepiota excoriata (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 135, 1871.
≡ *Agaricus excoriatus* Schaeff.:Fr. 1774.
Lepiota granulosa var. *amianthina* (Scop.) P.Kumm., *Führer Pilzk.*: 136, 1871.
≡ *Agaricus amianthinus* Scop. 1772.
≡ *Agaricus granulosus* * *amianthinus* (Scop.) Fr. 1838.
Lepiota granulosa var. *carcharias* (Pers.) P.Kumm., *Führer Pilzk.*: 136, 1871.
≡ *Agaricus carcharias* Pers. 1794.
≡ *Agaricus granulosus* * *carcharias* (Pers.) Fr. 1838.
Lepiota mastoidea (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 135, 1871.
≡ *Agaricus mastoideus* Fr.:Fr. 1821.
Lepiota mesomorpha (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 136, 1871.
≡ *Agaricus mesomorphus* Bull.:Fr. 1791.

Lepiota naucina (Fr) P.Kumm., *Führer Pilzk.*: 136, 1871.
≡ *Agaricus naucinus* Fr. 1838.
Lepiota seminuda (Lasch) P.Kumm., *Führer Pilzk.*: 136, 1871.
≡ *Agaricus seminudus* Lasch 1828.
Leptonia (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 24, 1871.
≡ *Agaricus* trib. *Leptonia* Fr.:Fr. 1821.
Leptonia anatina (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 96, 1871.
≡ *Agaricus anatinus* Lasch:Fr. 1829.
Leptonia asprella (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 96, 1871.
≡ *Agaricus asprellus* Fr.:Fr. 1821.
Leptonia chalybea (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 96, 1871, as "*chalybaea*".
≡ *Agaricus chalybeus* Pers.:Fr. 1801.
Leptonia euchlora (Lasch ex Fr.) P.Kumm., *Führer Pilzk.*: 96, 1871, as "*euchlorus*".
≡ *Agaricus euchlorus* Lasch ex Fr. 1838.
Leptonia euchroa (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 96, 1871, as "*euchrous*".
≡ *Agaricus euchrous* Pers.:Fr. 1801.
Leptonia linkii (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 96, 1871.
≡ *Agaricus linkii* Fr.:Fr. 1818.
Leptonia nefrens (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 96, 1871.
≡ *Agaricus nefrens* Fr.:Fr. 1821.
Leptonia placida (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 96, 1871.
≡ *Agaricus placidus* Fr.:Fr. 1818.
Leptonia serrulata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 96, 1871.
≡ *Agaricus serrulatus* Fr.:Fr. 1818.
Leucopus P.Kumm., *Führer Pilzk.*: 22, 1871, gen. nov.
Limacium (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 25, 1871.
≡ *Agaricus* trib. *Limacium* Fr.:Fr. 1821.
≡ *Hygrophorus* trib. *Limacium* (Fr.:Fr.) Fr. 1838.
Limacium chrysodon (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 118, 1871.
≡ *Agaricus chrysodon* Batsch:Fr. 1789.
≡ *Hygrophorus chrysodon* (Batsch:Fr.) Fr. 1838.
Limacium discoideum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 119, 1871.
≡ *Agaricus discoideus* Pers.:Fr. 1801.
≡ *Hygrophorus discoideus* (Pers.:Fr.) Fr. 1838.
Limacium eburneum (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 119, 1871.
≡ *Agaricus eburneus* Bull.:Fr. 1782–83.
≡ *Hygrophorus eburneus* (Bull.:Fr.) Fr. 1838.
Limacium eburneum var. *cossus* (Sowerby) P.Kumm., *Führer Pilzk.*: 119, 1871.
≡ *Agaricus cossus* Sowerby 1799.
≡ *Hygrophorus cossus* (Sowerby) Fr. 1838.
≡ *Agaricus eburneus* b. *cossus* (Sowerby) Rabenh. 1844.
Limacium eburneum var. *lutescens* (Rabenh.) P.Kumm., *Führer Pilzk.*: 119, 1871.
≡ *Agaricus eburneus* c. *lutescens* Rabenh. 1844.
Limacium eburneum var. *pudorinum* (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 119, 1871, as "*pudorina*".
≡ *Agaricus pudorinus* Fr.:Fr. 1821.
≡ *Hygrophorus pudorinus* (Fr..:Fr.) Fr. 1838.
≡ *Agaricus eburneus* d. *pudorinus* (Fr.:Fr.) Rabenh. 1844.
Limacium fuscoalbum (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 119, 1871.
≡ *Agaricus fuscoalbus* Lasch:Fr. 1829.
≡ *Hygrophorus fuscoalbus* (Lasch:Fr.) Fr. 1838.
Limacium hypothejum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 119, 1871.
≡ *Agaricus hypothejus* Fr.:Fr. 1818.
≡ *Hygrophorus hypothejus* (Fr.:Fr.) Fr. 1838.
Limacium limacinum (Scop.:Fr.) P.Kumm., *Führer Pilzk.*: 118, 1871.
≡ *Agaricus limacinus* Scop.:Fr. 1772.
≡ *Hygrophorus limacinus* (Scop.:Fr.) Fr. 1838.

Limacium olivaceoalbum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 119, 1871.
≡ *Agaricus olivaceoalbus* Fr.:Fr. 1815.
≡ *Hygrophorus olivaceoalbus* (Fr.:Fr.) Fr. 1838.

Limacium purpurascens (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 118, 1871.
≡ *Agaricus purpurascens* Alb. & Schwein.:Fr. 1805.
≡ *Hygrophorus purpurascens* (Alb. & Schwein.:Fr.) Fr. 1838.

Limacium pustulatum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 119, 1871.
≡ *Agaricus pustulatus* Pers.:Fr. 1801.
≡ *Hygrophorus pustulatus* (Pers.:Fr.) Fr. 1838.

Limacium pustulatum var. *agathosmum* (Fr.) P.Kumm., *Führer Pilzk.*: 119, 1871, as "*agathosma*".
≡ *Agaricus agathosmus* Fr. 1815.
≡ *Hygrophorus agathosmus* (Fr.) Fr. 1838.
≡ *Agaricus pustulatus* a. *agathosmus* (Fr.) Rabenh. 1844.

Limacium tephroleucum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 119, 1871, as "*thephroleucum*".
≡ *Agaricus tephroleucus* Pers.:Fr. 1801.
≡ *Hygrophorus tephroleucus* (Pers.:Fr.) Fr. 1838.

Marasmius stipitarius (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 113, 1871.
≡ *Agaricus stipitarius* Fr.:Fr. 1821.

Mycena acicula (Schaeff.) P.Kumm., *Führer Pilzk.*: 109, 1871.
≡ *Agaricus acicula* Schaeff. 1774.

Mycena alcalina (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871, as "*alcalinea*".
≡ *Agaricus alcalinus* Fr.:Fr. 1818.

Mycena alliacea (Jacq.:Fr.) P.Kumm., *Führer Pilzk.*: 107, 1871.
≡ *Agaricus alliaceus* Jacq.:Fr. 1773.

Mycena atromarginata (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871.
≡ *Agaricus atromarginatus* Lasch:Fr. 1828.

Mycena capillaris (Schumach.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus capillaris* Schumach.:Fr. 1803.

Mycena chlorantha (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 110, 1871, as "*chloranthus*".
≡ *Agaricus chloranthus* Fr.:Fr. 1818.

Mycena citrinella (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871, as "*citronella*".
≡ *Agaricus citrinellus* Pers.:Fr. 1800.

Mycena cohaerens (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 111, 1871.
≡ *Agaricus cohaerens* Pers.:Fr. 1801.

Mycena crocata (Schrad.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus crocatus* Schrad.:Fr. 1794.

Mycena echinipes (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus echinipes* Lasch:Fr. 1828.

Mycena elegans (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871.
≡ *Agaricus elegans* Pers.:Fr. 1801.

Mycena excisa (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 111, 1871.
≡ *Agaricus excisus* Lasch:Fr. 1829.

Mycena farrea (Lasch ex Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871.
≡ *Agaricus farreus* Lasch ex Fr. 1838.

Mycena filopes (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 110, 1871.
≡ *Agaricus filopes* Bull.:Fr. 1787–88.

Mycena galericulata var. *hiemalis* (Lasch) P.Kumm., *Führer Pilzk.*: 111, 1871.
≡ *Agaricus galericulatus* δ *hiemalis* Lasch 1829.

Mycena galericulata var. *laevigata* (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 111, 1871.
≡ *Agaricus laevigatus* Lasch:Fr. 1828.

Mycena galericulata var. *parabolica* (Fr.) P.Kumm., *Führer Pilzk.*: 111, 1871.
≡ *Agaricus parabolicus* Fr. 1838.
≡ *Agaricus galericulatus* c. *parabolicus* (Fr.) Rabenh. 1844.

Mycena galopus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus galopus* Pers.:Fr. 1800.

Mycena haematopus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus haematopus* Pers.:Fr. 1800.

Mycena janthina (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 110, 1871.
≡ *Agaricus janthinus* Fr.:Fr. 1821.
Mycena lactea (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 110, 1871.
≡ *Agaricus lacteus* Pers.:Fr. 1801.
Mycena lineata (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 110, 1871.
≡ *Agaricus lineatus* Bull.:Fr. 1791.
Mycena marginella (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871.
≡ *Agaricus marginellus* Pers.:Fr. 1801.
Mycena metata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871.
≡ *Agaricus metatus* Fr.:Fr. 1821.
Mycena plicosa (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871.
≡ *Agaricus metatus* β *plicosus* Fr.:Fr. 1821.
≡ *Agaricus plicosus* (Fr.:Fr.) Fr. 1838.
Mycena prasiosma (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus prasiosmus* Fr.:Fr. 1818.
Mycena pterigena (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus pterigenus* Fr.:Fr. 1815.
Mycena pterigena var. *saccharina* (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871, as "*saecherinus*".
≡ *Agaricus saccharinus* Batsch:Fr. 1786.
≡ *Agaricus epiphyllus* β *saccharinus* (Batsch:Fr.) Pers. 1801
≡ *Agaricus pterigenus* β *saccharinus* (Batsch:Fr.) Fr. 1821
Mycena pubescens (Rabenh.) P.Kumm., *Führer Pilzk.*: 111, 1871.
≡ *Agaricus pubescens* Rabenh. 1844.
Mycena pura (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 107, 110, 1871.
≡ *Agaricus purus* Pers.:Fr. 1794.
Mycena raeborhiza (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 111, 1871.
≡ *Agaricus raeborhizus* Lasch:Fr. 1829.
Mycena rosella (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871.
≡ *Agaricus rosellus* Fr.:Fr. 1821.
Mycena rubromarginata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 109, 1871.
≡ *Agaricus rubromarginatus* Fr.:Fr. 1815.
Mycena sanguinolenta (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus sanguinolentus* Alb. & Schwein.:Fr. 1805.
Mycena stylobates (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus stylobates* Pers.:Fr. 1801.
Mycena supina (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus supinus* Fr.:Fr. 1821.
Mycena torquata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus torquatus* Fr.:Fr. 1821.
Mycena vulgaris (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 108, 1871.
≡ *Agaricus vulgaris* Pers.:Fr. 1794.
Mycena zephirus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 110, 1871, as "*zephyrus*".
≡ *Agaricus zephirus* Fr.:Fr. 1815.
Myxacium (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 22, 1871.
≡ *Agaricus* trib. *Myxacium* Fr.:Fr. 1821.
≡ *Cortinarius* trib. *Myxacium* (Fr.:Fr.) Fr. 1838.
Myxacium alutipes (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871.
≡ *Agaricus alutipes* Lasch:Fr. 1828.
≡ *Cortinarius alutipes* (Lasch:Fr.) Fr. 1838.
Myxacium arquatum (Fr.) P.Kumm., *Führer Pilzk.*: 92, 1871.
≡ *Cortinarius arquatus* Fr. 1838.
Myxacium barbatum (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 91, 1871.
≡ *Agaricus barbatus* Batsch:Fr. 1783.
Myxacium calochroum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 92, 1871, as "*callochrous*".
≡ *Agaricus calochrous* Pers.:Fr. 1801.
≡ *Cortinarius calochrous* (Pers.:Fr.) Fr. 1838.

Myxacium collinitum (Sowerby:Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871.
≡ *Agaricus collinitus* Sowerby:Fr. 1798.
≡ *Cortinarius collinitus* (Sowerby:Fr.) Fr. 1838.
Myxacium croceocaeruleum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 92, 1871, as "*croceocoeruleum*".
≡ *Agaricus croceocaeruleus* Pers.:Fr. 1798.
≡ *Cortinarius croceocaeruleus* (Pers.:Fr.) Fr. 1838.
Myxacium decolorans (Fr.) P.Kumm., *Führer Pilzk.*: 91, 1871.
≡ *Agaricus decolorans* Pers. 1796, nom. illegit., non Fr.:Fr. 1821.
≡ *Cortinarius decolorans* Fr. 1838, nom. nov.
Myxacium decoloratum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 91, 1871.
≡ *Agaricus decloratus* Fr.:Fr. 1821.
≡ *Cortinarius decoloratus* (Fr.:Fr.) Fr. 1838.
Myxacium elegantius (Fr.) P.Kumm., *Führer Pilzk.*: 92, 1871.
≡ *Agaricus multiformis* β *elegantior* Fr. 1818.
≡ *Cortinarius elegantior* (Fr.) Fr. 1838.
≡ *Agaricus elegantior* (Fr.) Rabenh. 1844.
Myxacium fulgens (Fr.) P.Kumm., *Führer Pilzk.*: 92, 1871.
≡ *Agaricus fulgens* Alb. & Schwein. 1805, nom. illegit., non Pers.:Fr. 1800.
≡*Cortinarius fulgens* Fr. 1838, nom. nov.
Myxacium glaucopus (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 92, 1871.
≡ *Agaricus glaucopus* Schaeff.:Fr. 1774.
≡ *Cortinarius glaucopus* (Schaeff.:Fr.) Fr. 1838.
Myxacium maculosum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 91, 1871.
≡ *Agaricus maculosus* Pers.:Fr. 1801.
≡ *Cortinarius maculosus* (Pers.:Fr.) Fr. 1838.
Myxacium mucosum (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871, as "*muscosum*".
≡ *Agaricus mucosus* Bull.:Fr. 1792.
≡ *Agaricus collinitus* β *mucosus* (Bull.:Fr.) Fr. 1821.
≡ *Cortinarius collinitus* * *mucosus* (Bull.:Fr.) Fr. 1838.
Myxacium nitidum (Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871.
≡ *Agaricus nitidus* Schaeff. 1774, nom. illegit., non Pers.:Fr. 1801.
≡ *Cortinarius nitidus* Fr. 1838, nom. nov.
Myxacium ochroleucum P.Kumm., *Führer Pilzk.*: 92, 1871, nom. nov.
≡ *Agaricus cyanus* Pers. 1801, nom. illegit., non *Agaricus cyaneus* Bull. 1783–84.
[non *Cortinarius ochroleucus* (Schaeff.:Fr.) Fr. 1838.]
Myxacium pluvium (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871.
≡ *Agaricus pluvius* Fr.:Fr. 1821.
≡ *Cortinarius pluvius* (Fr.:Fr.) Fr. 1838.
Myxacium porphyropus (Alb. & Schwein.) P.Kumm., *Führer Pilzk.*: 91, 1871.
≡ *Agaricus porphyropus* Alb. & Schwein. 1805.
≡ *Cortinarius porphyropus* (Alb. & Schwein.) Fr. 1838.
Myxacium rufoolivaceum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871.
≡ *Agaricus rufoolivaceus* Pers.:Fr. 1801.
≡ *Cortinarius rufoolivaceus* (Pers.:Fr.) Fr. 1838.
Myxacium scaurum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871.
≡ *Agaricus scaurus* Fr.:Fr. 1818.
≡ *Cortinarius scaurus* (Fr.:Fr.) Fr. 1838.
Myxacium subtortum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 92, 1871.
≡ *Agaricus subtortus* Pers.:Fr. 1801.
≡ *Cortinarius subtortus* (Pers.:Fr.) Fr. 1838.
Myxacium turbinatum (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 92, 1871.
≡ *Agaricus turbinatus* Bull.:Fr. 1782–83.
≡ *Cortinarius turbinatus* (Bull.:Fr.) Fr. 1838.
Myxacium vibratile (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 93, 1871.
≡ *Agaricus vibratilis* Fr.:Fr. 1821.
≡ *Cortinarius vibratilis* (Fr.:Fr.) Fr. 1838.
Naucoria (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 22, 1871.
≡ *Agaricus* trib. *Naucoria* Fr.:Fr. 1821.

Naucoria badipus (Pers.) P.Kumm., *Führer Pilzk.*: 77, 1871.

≡ *Agaricus badipus* Pers. 1801.

Naucoria centunculus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 78, 1871.

≡ *Agaricus centunculus* Fr.:Fr. 1821.

Naucoria cerodes (Fr.) P.Kumm., *Führer Pilzk.*: 77, 1871.

≡ *Agaricus cerodes* Fr. 1838.

Naucoria christinae (Fr.) P.Kumm., *Führer Pilzk.*: 78, 1871.

≡ *Agaricus christinae* Fr. 1838.

Naucoria conspersa (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 76, 1871.

≡ *Agaricus conspersus* Pers.:Fr. 1800.

Naucoria cucumis (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 78, 1871.

≡ *Agaricus cucumis* Pers.:Fr. 1796.

Naucoria escharioides (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 76, 1871, as "*escharoides*".

≡ *Agaricus escharioides* Fr.:Fr. 1818.

Naucoria furfuracea (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 77, 1871.

≡ *Agaricus furfuraceus* Pers.:Fr. 1801.

Naucoria furfuracea var. *trigonophylla* (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 77, 1871, as "*trigonophyllus*". ≡ *Agaricus trigonophyllus* Lasch:Fr. 1828.

≡ *Agaricus furfuraceus* b. *trigonophyllus* (Lasch:Fr.) Rabenh. 1844.

Naucoria graminicola (Nees:Fr.) P.Kumm., *Führer Pilzk.*: 76, 1871.

≡ *Agaricus graminicola* Nees:Fr. 1816–17.

Naucoria inquilina (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 76, 1871.

≡ *Agaricus inquilinus* Fr.:Fr. 1818.

≡ *Agaricus furfuraceus* c. *inquilinus* (Fr.:Fr.) Rabenh. 1844.

Naucoria melinoides (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 77, 1871.

≡ *Agaricus melinoides* Bull.:Fr. 1792–93.

Naucoria myosotis (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 77, 1871.

≡ *Agaricus myosotis* Fr.:Fr. 1818.

Naucoria pediades (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 78, 1871.

≡ *Agaricus pediades* Fr.:Fr. 1821.

Naucoria pusilla (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 77, 1871.

≡ *Agaricus pusillus* Fr.:Fr. 1821, p. 264, non (Pers.:Fr.) Fr. 1821, p. 279.

Naucoria sobria (Fr.) P.Kumm., *Führer Pilzk.*: 77, 1871.

≡ *Agaricus furfuraceus* γ *sobrius* Fr. 1818.

≡ *Agaricus sobrius* (Fr.) Secr. 1833.

Naucoria temulenta (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 77, 1871.

≡ *Agaricus temulentus* Fr.:Fr. 1821.

Naucoria undulata (Jungh.:Fr.) P.Kumm., *Führer Pilzk.*: 77, 1871.

≡ *Agaricus undulatus* Jungh.:Fr. 1830.

Nolanea (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 24, 1871.

≡ *Agaricus* trib. *Nolanea* Fr.:Fr. 1821.

Nolanea cetrata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 95, 1871.

≡ *Agaricus cetratus* Fr.:Fr. 1818.

Nolanea clandestina (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 95, 1871.

≡ *Agaricus clandestinus* Fr.:Fr. 1818.

Nolanea exilis (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 95, 1871.

≡ *Agaricus exilis* Fr.:Fr. 1818.

Nolanea fumosa P.Kumm., *Führer Pilzk.*: 95, 1871, nom. nov.

≡ *Agaricus fumosus* Rabenh. 1844, nom. illegit., non Pers.:Fr. 1801.

Nolanea hirtipes (Schumach.:Fr.) P.Kumm., *Führer Pilzk.*: 95, 1871.

≡ *Agaricus hirtipes* Schumach.:Fr. 1803.

Nolanea icterina (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 95, 1871.

≡ *Agaricus icterinus* Fr.:Fr. 1821.

Nolanea kretzschmarii (Rabenh.) P.Kumm., *Führer Pilzk.*: 95, 1871.

≡ *Agaricus kretzschmarii* Rabenh. 1844.

Nolanea pascua (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 95, 1871.

≡ *Agaricus pascuus* Pers.:Fr. 1800.

Nolanea vinacea (Scop.) P.Kumm., *Führer Pilzk.*: 95, 1871.
≡ *Agaricus vinaceus* Scop. 1772.
Omphalia atripes (Rabenh.) P.Kumm., *Führer Pilzk.*: 106, 1871.
≡ *Agaricus atripes* Rabenh. 1840.
Omphalia campanella (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 107, 1871.
≡ *Agaricus campanella* Batsch:Fr. 1783.
Omphalia chrysophylla (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 107, 1871.
≡ *Agaricus chrysophyllus* Fr.:Fr. 1821.
Omphalia epichysium (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 107, 1871.
≡ *Agaricus epichysium* Pers.:Fr. 1794.
Omphalia epichysium var. *icmadophila* (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 107, 1871, as "Abart".
≡ *Agaricus epichysium* β *icmadophilus* Pers.:Fr. 1801.
Omphalia fibula (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 106, 1871.
≡ *Agaricus fibula* Bull.:Fr. 1783–84.
Omphalia gracillima P.Kumm., *Führer Pilzk.*: 106, 1871, nom. nov.
≡ *Agaricus gracillimus* Weinm. 1836, nom. illegit., non Weinm. 1826.
Omphalia integrella (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 106, 1871.
≡ *Agaricus integrellus* Pers.:Fr. 1800.
Omphalia microscopica (Wirtg.) P.Kumm., *Führer Pilzk.*: 106, 1871.
≡ *Agaricus microscopicus* Wirtg. 1835.
Omphalia polyadelpha (Lasch) P.Kumm., *Führer Pilzk.*: 106, 1871, as "*polyadelphus*".
≡ *Agaricus polyadelphus* Lasch 1828.
Omphalia pyxidata (Bull. ex Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 107, 1871.
≡ *Agaricus pyxidatus* Bull. ex Pers.:Fr. 1801.
Omphalia scyphoides (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 106, 1871.
≡ *Agaricus scyphoides* Fr.:Fr. 1821.
Omphalia stellata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 106, 1871.
≡ *Agaricus stellatus* Fr.:Fr. 1815.
Omphalia tricolor (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 106, 1871.
≡ *Agaricus tricolor* Alb. & Schwein.:Fr. 1805.
Omphalia umbellifera (L.:Fr.) P.Kumm., *Führer Pilzk.*: 107, 1871.
≡ *Agaricus umbelliferus* L.:Fr. 1753.
Pholiota (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 22, 1871, nom. cons.
≡ *Agaricus* trib. *Pholiota* Fr.:Fr. 1821.
Pholiota adiposa (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 83, 1871.
≡ *Agaricus adiposus* Batsch:Fr. 1786.
Pholiota aurea (Matt.:Fr.) P.Kumm., *Führer Pilzk.*: 85, 1871.
≡ *Agaricus aureus* Matt.:Fr. 1779.
Pholiota aurivella (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 83, 1871, as "*aurivellus*".
≡ *Agaricus aurivellus* Batsch:Fr. 1786.
Pholiota aurivella var. *pallida* (Rabenh.) P.Kumm., *Führer Pilzk.*: 83, 1871.
≡ *Agaricus aurivellus* b. *pallidus* Rabenh. 1844.
Pholiota caperata (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 84, 1871.
≡ *Agaricus caperatus* Pers.:Fr. 1796.
Pholiota dura (Bolton) P.Kumm., *Führer Pilzk.*: 84, 1871.
≡ *Agaricus durus* Bolton 1788.
Pholiota flammans (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 84, 1871.
≡ *Agaricus flammans* Batsch:Fr. 1783.
Pholiota infracta (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 85, 1871.
≡ *Agaricus infractus* Pers.:Fr. 1800.
Pholiota lata (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 85, 1871.
≡ *Agaricus latus* Pers.:Fr. 1801.
Pholiota muricata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 83, 1871.
≡ *Agaricus muricatus* Fr.:Fr. 1821.
Pholiota muricata var. *curvipes* P.Kumm., *Führer Pilzk.*: 83, 1871, as "Abart", nom. nov.
≡ *Agaricus curvipes* Alb. & Schwein. 1805, nom. illegit., non Pers. 1801.

Pholiota mutabilis (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 83, 1871.
≡ *Agaricus mutabilis* Schaeff.:Fr. 1774.
Pholiota praecox (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 85, 1871.
≡ *Agaricus praecox* Pers.:Fr. 1800.
Pholiota praecox var. *pusilla* (Rabenh.) P.Kumm., *Führer Pilzk.*: 85, 1871, as "Abart".
≡ *Agaricus praecox* b. *pusillus* Rabenh. 1844.
Pholiota radicosa (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 84, 1871.
≡ *Agaricus radicosus* Bull.:Fr. 1783–84.
Pholiota separata (L.) P.Kumm., *Führer Pilzk.*: 84, 1871, as "*separata (semiovata)*".
≡ *Agaricus separatus* L. 1753.
Pholiota spectabilis (Weinm.:Fr.) P.Kumm., *Führer Pilzk.*: 84, 1871.
≡ *Agaricus spectabilis* Weinm.:Fr. 1822.
Pholiota squarrosa (Oeder:Fr.) P.Kumm., *Führer Pilzk.*: 84, 1871.
≡ *Agaricus squarrosus* Oeder:Fr. 1770.
Pholiota togularis (Bull. ex Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 85, 1871.
≡ *Agaricus togularis* Bull. ex Pers.:Fr. 1801.
Pholiota tuberculosa (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 83, 1871.
≡ *Agaricus tuberculosus* Schaeff.:Fr. 1774.
Pholiota variecolor (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 85, 1871.
≡ *Agaricus variecolor* Pers.:Fr. 1801.
Pleurotus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 24, 1871, nom. cons.
≡ *Agaricus* trib. *Pleurotus* Fr.:Fr. 1821.
Pleurotus albertinii (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 104, 1871, as "*albertini*".
≡ *Agaricus albertinii* Fr.:Fr. 1821.
Pleurotus applicatus (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus applicatus* Batsch:Fr. 1786.
Pleurotus atrocaeruleus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 104, 1871, as "*atrocoeruleus*".
≡ *Agaricus atrocaeruleus* Fr.:Fr. 1815.
Pleurotus carneotomentosus (Batsch) P.Kumm., *Führer Pilzk.*: 106, 1871.
≡ *Agaricus carneotomentosus* Batsch 1783.
Pleurotus conchatus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus conchatus* Bull.:Fr. 1787.
Pleurotus corticatus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 104, 1871.
≡ *Agaricus corticatus* Fr.:Fr. 1815, p. 92, non Fr. 1815, p. 22.
Pleurotus dryinus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 104, 1871.
≡ *Agaricus dryinus* Pers.:Fr. 1800.
Pleurotus lignatilis (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus lignatilis* Fr.:Fr. 1821.
Pleurotus nidulans (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus nidulans* Pers.:Fr. 1798.
Pleurotus ostreatus (Jacq.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus ostreatus* Jacq.:Fr. 1774.
Pleurotus perpusillus (Lumn.:Fr.) P.Kumm., *Führer Pilzk.*: 104, 1871.
≡ *Agaricus perpusillus* Lumn.:Fr. 1791.
Pleurotus planus (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus planus* Alb. & Schwein.:Fr. 1805.
Pleurotus porrigens (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 104, 1871.
≡ *Agaricus porrigens* Pers.:Fr. 1796.
Pleurotus salignus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus salignus* Pers.:Fr. 1801.
Pleurotus septicus (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 104, 1871.
≡ *Agaricus septicus* Fr.:Fr. 1821.
Pleurotus serotinus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 104, 1871.
≡ *Agaricus serotinus* Pers.:Fr. 1793.
Pleurotus striatulus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus striatulus* Pers.:Fr. 1801.

Pleurotus stypticus (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus stypticus* Bull.:Fr. 1783.
Pleurotus tremulus (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus tremulus* Schaeff.:Fr. 1774.
Pleurotus ulmarius (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 105, 1871.
≡ *Agaricus ulmarius* Bull.:Fr. 1791.
Pleurotus unguicularis (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 104, 1871.
≡ *Agaricus unguicularis* Fr.:Fr. 1828.
Pluteus cervinus P.Kumm., *Führer Pilzk.*: 99, 1871, nom. nov.
≡ *Agaricus cervinus* Schaeff. 1774, nom. illegit., non Hoffm.:Fr. 1789.
Pluteus leoninus (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus leoninus* Schaeff.:Fr. 1774.
Pluteus nanus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus nanus* Pers.:Fr. 1801.
Pluteus pellitus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus pellitus* Pers.:Fr. 1801.
Pluteus phlebophorus (Ditmar:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus phlebophorus* Ditmar:Fr. 1813.
Pluteus roseoalbus (Hornem.:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus roseoalbus* Hornem.:Fr. 1819.
Pluteus salicinus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 99, 1871.
≡ *Agaricus salicinus* Pers.:Fr. 1801.
Pluteus umbrosus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 98, 1871.
≡ *Agaricus umbrosus* Pers.:Fr. 1798.
Polyporus bulliardii (Fr.) P.Kumm., *Führer Pilzk.*: 59, 1871, as "*J. bulliardi*", nom. illegit., non (Fr.:Fr.) Pers. 1825.
≡ *Boletus suaveolens* Bull.:Fr. 1787–88, nom. illegit., non L.:Fr. 1753.
≡ *Trametes bulliardii* Fr. 1838, nom. nov.
Polyporus confragosus (Bolton:Fr.) P.Kumm., *Führer Pilzk.*: 59, 1871.
≡ *Boletus confragosus* Bolton:Fr. 1792.
≡ *Daedalea confragosa* (Bolton:Fr.) Pers. 1801.
≡ *Trametes confragosa* (Bolton:Fr.) Rabenh. 1844.
Polyporus gibbosus (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 59, 1871, nom. illegit., non Blume & Nees:Fr. 1826.
≡ *Merulius gibbosus* Pers.:Fr. 1796.
≡ *Daedalea gibbosa* (Pers.:Fr.) Pers. 1801.
≡ *Trametes gibbosa* (Pers.:Fr.) Fr. 1838.
Polyporus reticulatus var. *corticola* (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 54, 1871, as "Abart".
≡ *Polyporus corticola* Fr.:Fr. 1821.
Polyporus rubescens (Alb. & Schwein.:Fr.) P.Kumm., *Führer Pilzk.*: 59, 1871.
≡ *Daedalea rubescens* Alb. & Schwein.:Fr. 1805.
≡ *Trametes rubescens* (Alb. & Schwein.:Fr.) Fr. 1838.
Psalliota (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 23, 1871.
≡ *Agaricus* trib. *Psalliota* Fr.:Fr. 1821.
Psalliota aeruginosa (Curtis:Fr.) P.Kumm., *Führer Pilzk.*: 73, 1871.
≡ *Agaricus aeruginosus* Curtis:Fr. 1786.
Psalliota arvensis (Schaeff.) P.Kumm., *Führer Pilzk.*: 74, 1871.
≡ *Agaricus arvensis* Schaeff. 1774.
Psalliota campestris (L.:Fr.) P.Kumm., *Führer Pilzk.*: 73, 1871.
≡ *Agaricus campestris* L.:Fr. 1753.
Psalliota campestris var. *praticola* (Vittad.) P.Kumm., *Führer Pilzk.*: 73, 1871.
≡ *Agaricus campestris* var. *praticola* Vittad. 1835.
Psalliota campestris var. *sylvicola* (Vittad.) P.Kumm., *Führer Pilzk.*: 73, 1871.
≡ *Agaricus campestris* var. *sylvicola* Vittad. 1835.
Psalliota campestris var. *vaporaria* (Pers.) P.Kumm., *Führer Pilzk.*: 73, 1871, as "*vaporarius*".
≡ *Agaricus campestris* β *vaporarius* Pers. 1801.
Psalliota cretacea (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 73, 1871.
≡ *Agaricus cretaceus* Bull.:Fr. 1788.

Psalliota echinata (Roth:Fr.) P.Kumm., *Führer Pilzk.*: 73, 1871.
≡ *Agaricus echinatus* Roth:Fr. 1800.
Psalliota melanosperma (Bull. ex Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 73, 1871.
≡ *Agaricus melanospermus* Bull. ex Pers.:Fr. 1801.
Psalliota semiglobata (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 72, 1871.
≡ *Agaricus semiglobatus* Batsch:Fr. 1786.
Psalliota spodophylla (Krombh.) P.Kumm., *Führer Pilzk.*: 72, 1871, as "*spodophyllus*".
≡ *Agaricus spodophyllus* Krombh. 1836.
Psalliota squamosa (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 73, 1871.
≡ *Agaricus squamosus* Pers.:Fr. 1801.
Psalliota stercoraria (Schumach.:Fr.) P.Kumm., *Führer Pilzk.*: 72, 1871.
≡ *Agaricus stercorarius* Schumach.:Fr. 1803.
Psalliota sylvatica (Schaeff.) P.Kumm., *Führer Pilzk.*: 73, 1871.
≡ *Agaricus sylvaticus* Schaeff. 1774.
Psathyra (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 20, 1871, nom. illegit., non Spreng. 1818.
≡ *Agaricus* trib. *Psathyra* Fr.:Fr. 1821.
Psathyra atomata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 70, 1871.
≡ *Agaricus atomatus* Fr.:Fr. 1821.
Psathyra cernua (Vahl:Fr.) P.Kumm., *Führer Pilzk.*: 70, 1871.
≡ *Agaricus cernuus* Vahl:Fr. 1790.
Psathyra conopila (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 70, 1871, as "*conopilus*".
≡ *Agaricus conopilus* Fr.:Fr. 1821.
Psathyra fagicola (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871.
≡ *Agaricus fagicola* Lasch:Fr. 1828.
Psathyra fatua (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 70, 1871.
≡ *Agaricus stipatus γ fatuus* Fr.:Fr. 1821.
≡ *Agaricus fatuus* (Fr.:Fr.) Fr. 1838.
Psathyra fibrillosa (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 70, 1871.
≡ *Agaricus fibrillosus* Pers.:Fr. 1801.
Psathyra gyroflexa (Fr.) P.Kumm., *Führer Pilzk.*: 70, 1871.
≡ *Agaricus gyroflexus* Fr. 1838.
Psathyra lacrymabunda (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871.
≡ *Agaricus lacrymabundus* Bull.:Fr. 1785.
Psathyra microrhiza (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 70, 1871.
≡ *Agaricus microrhizus* Lasch:Fr. 1828.
Psathyra spadiceogrisea (Schaeff.) P.Kumm., *Führer Pilzk.*: 70, 1871.
≡ *Agaricus spadiceogriseus* Schaeff. 1774.
Psathyra torpens (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 70, 1871.
≡ *Agaricus torpens* Fr.:Fr. 1821.
Psilocybe (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 21, 1871.
≡ *Agaricus* trib. *Psilocybe* Fr.:Fr. 1821.
Psilocybe bullacea (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871.
≡ *Agaricus bullaceus* Bull.:Fr. 1792–93.
Psilocybe campanulata (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871.
≡ *Agaricus campanulatus* Bull.:Fr. 1792.
Psilocybe canobrunnea (Batsch:Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871.
≡ *Agaricus canobrunneus* Batsch:Fr. 1786.
Psilocybe coprophila (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871.
≡ *Agaricus coprophilus* Bull.:Fr. 1792–93.
Psilocybe montana (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871.
≡ *Agaricus montanus* Pers.:Fr. 1796.
Psilocybe obtusata (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871.
≡ *Agaricus obtusus* Pers. 1801, nom. illegit., non Fr.:Fr. 1821.
≡ *Agaricus obtusatus* Fr.:Fr. 1821, nom. nov.
Psilocybe semilanceata (Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871, as "*semilanceolata*".
≡ *Agaricus semilanceatus* Fr. 1818.

Psilocybe spadicea P.Kumm., *Führer Pilzk.*: 71, 1871, nom. nov.
≡ *Agaricus spadiceus* Schaeff. 1774, nom. illegit., non Scop. 1772.

Psilocybe ventricosa (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 71, 1871.
≡ *Agaricus ventricosus* Bull.:Fr. 1789.

Raphanozon P.Kumm., *Führer Pilzk.*: 22, 1871, gen. nov., nom. rej. [≡ *Telamonia* (Fr.:Fr.) Wünsche 1877.]

Russula furcata var. *heterophylla* (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 102, 1871, as "Abart".
≡ *Agaricus furcatus* β *heterophyllus* Fr.:Fr. 1821.
≡ *Russula heterophylla* (Fr.:Fr.) Fr. 1838.

Russula narcotica P.Kumm., *Führer Pilzk.*: 100, 1871, sp. nov.

Thelephora clavata (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 46, 1871.
≡ *Merulius clavatus* Pers.:Fr. 1796.
≡ *Cantharellus clavatus* (Pers.:Fr.) Fr. 1821.

?*Thelephora florida* P.Kumm., *Führer Pilzk.*: 46, 1871, as "*florida (sinuosa)*", sp. nov. OR PERHAPS:

?*Thelephora floriformis* (Sowerby) P.Kumm., *Führer Pilzk.*: 46, 1871, as "*florida* [sic] *(sinuosa)*".
≡ *Helvella floriformis* Sowerby 1796–97 [= *Cantharellus sinuosus*, fide Fries 1828.]

Tricholoma albellum P.Kumm., *Führer Pilzk.*: 131, 1871, nom. nov.
≡ *Agaricus albellus* DC. 1805, nom. illegit., non Scop. 1772.

Tricholoma albobrunneum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 130, 1871.
≡ *Agaricus albobrunneus* Pers.:Fr. 1801.

Tricholoma album (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 131, 1871.
≡ *Agaricus albus* Schaeff.:Fr. 1774.

Tricholoma amethystinum (Scop.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus amethystinus* Scop. 1772.

Tricholoma brevipes (Bull.) P.Kumm., *Führer Pilzk.*: 133, 1871.
≡ *Agaricus brevipes* Bull. 1791.

Tricholoma carneum (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus carneus* Bull.:Fr. 1792.

Tricholoma cerinum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 133, 1871.
≡ *Agaricus cerinus* Pers.:Fr. 1794.

Tricholoma chrysenterum (Bull. ex Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 133, 1871.
≡ *Agaricus chrysenterus* Bull. ex Pers.:Fr. 1801.

Tricholoma columbetta (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 131, 1871.
≡ *Agaricus columbetta* Fr.:Fr. 1821.

Tricholoma columbetta var. *impolitum* (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 131, 1871, as "Abart".
≡ *Agaricus impolitus* Lasch:Fr. 1829.
≡ *Agaricus columbetta* c. *impolitus* (Lasch:Fr.) Rabenh. 1844.

Tricholoma cuneifolium (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus cuneifolius* Fr.:Fr. 1818.

Tricholoma equestre (L.:Fr.) P.Kumm., *Führer Pilzk.*: 130, 1871.
≡ *Agaricus equestris* L.:Fr. 1789.

Tricholoma flavobrunneum (Fr.) P.Kumm., *Führer Pilzk.*: 130, 1871.
≡ *Agaricus flavobrunneus* Fr. 1818.

Tricholoma flavum P.Kumm., *Führer Pilzk.*: 133, 1871, nom. nov.
≡ *Agaricus flavus* Lasch 1829, nom. illegit., non With. 1796.

Tricholoma fucatum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 130, 1871.
≡ *Agaricus fucatus* Fr.:Fr. 1821.

Tricholoma gambosum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 131, 1871.
≡ *Agaricus gambosus* Fr.:Fr. 1821.

Tricholoma granulatum (Schaeff.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus granulatus* Schaeff. 1774.

Tricholoma graveolens (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 131, 1871.
≡ *Agaricus graveolens* Pers.:Fr. 1801.

Tricholoma guttatum P.Kumm., *Führer Pilzk.*: 132, 1871, nom. nov.
≡ *Agaricus guttatus* Schaeff. 1774, nom. illegit., non Pers.:Fr. 1793.

Tricholoma imbricatum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 133, 1871.
≡ *Agaricus imbricatus* Fr.:Fr. 1815.

Tricholoma ionides (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus ionides* Bull.:Fr. 1792.
Tricholoma irinum (Fr.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus irinus* Fr. 1838.
Tricholoma leucoxanthum (Pers.) P.Kumm., *Führer Pilzk.*: 130, 1871.
≡ *Agaricus leucoxanthus* Pers. 1801.
Tricholoma luridum (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus luridus* Schaeff.:Fr. 1774.
Tricholoma melaleucum (Pers.:Fr.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus melaleucus* Pers.:Fr. 1801.
Tricholoma nudum (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus nudus* Bull.:Fr. 1790.
Tricholoma personatum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 132, 1871.
≡ *Agaricus personatus* Fr.:Fr. 1818.
Tricholoma pomonae (Lenz) P.Kumm., *Führer Pilzk.*: 131, 1871.
≡ *Agaricus pomonae* Lenz 1831.
Tricholoma prasinum (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 130, 1871.
≡ *Agaricus prasinus* Schaeff.:Fr. 1774.
Tricholoma rutilans (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 133, 1871.
≡ *Agaricus rutilans* Schaeff.:Fr. 1774.
Tricholoma rutilans var. *variegatum* (Rabenh.) P.Kumm., *Führer Pilzk.*: 133, 1871, as "*variegata*", "Abart".
≡ *Agaricus variegatus* Scop. 1772, nom. illegit., non Pers.:Fr. 1801.
≡ *Agaricus rutilans* b. *variegatus* Rabenh. 1844, nom. nov.
Tricholoma saponaceum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 133, 1871.
≡ *Agaricus saponaceus* Fr.:Fr. 1818.
Tricholoma sordidum (Schumach.:Fr.) P.Kumm., *Führer Pilzk.*: 134, 1871.
≡ *Agaricus sordidus* Schumach.:Fr. 1803.
Tricholoma sulphureum (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 133, 1871.
≡ *Agaricus sulphureus* Bull.:Fr. 1783–84.
Tricholoma terreum (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 134, 1871.
≡ *Agaricus terreus* Schaeff.:Fr. 1774.
Tricholoma terreum var. *argyraceum* (Bull.) P.Kumm., *Führer Pilzk.*: 134, 1871, as "Abart".
≡ *Agaricus argyraceus* Bull. 1789.
≡ *Agaricus terreus * argyraceus* (Bull.) Fr. 1838.
Tricholoma tigrinum P.Kumm., *Führer Pilzk.*: 131, 1871, nom. nov.
≡ *Agaricus tigrinus* Schaeff. 1774, nom. illegit., non Bull.:Fr. 1781–82.
Tricholoma urens P.Kumm., *Führer Pilzk.*: 131, 1871, sp. nov.
Tricholoma ustale (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 130, 1871.
≡ *Agaricus ustalis* Fr.:Fr. 1818.
Tricholoma vaccinum (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 133, 1871.
≡ *Agaricus vaccinus* Schaeff.:Fr. 1774.
Tricholoma virgatum (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 134, 1871.
≡ *Agaricus virgatus* Fr.:Fr. 1818.
Volvaria (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 23, 1871.
≡ *Agaricus* trib. *Volvaria* Fr.:Fr. 1821.
Volvaria bombycina (Schaeff.:Fr.) P.Kumm., *Führer Pilzk.*: 99, 1871.
≡ *Agaricus bombycinus* Schaeff.:Fr. 1774.
Volvaria parvula (Weinm.) P.Kumm., *Führer Pilzk.*: 99, 1871.
≡ *Agaricus parvulus* Weinm. 1836.
Volvaria rhodomelas (Lasch:Fr.) P.Kumm., *Führer Pilzk.*: 99, 1871.
≡ *Agaricus rhodomelas* Lasch:Fr. 1829.
Volvaria speciosa (Fr.:Fr.) P.Kumm., *Führer Pilzk.*: 99, 1871.
≡ *Agaricus speciosus* Fr.:Fr. 1818.
Volvaria volvacea (Bull.:Fr.) P.Kumm., *Führer Pilzk.*: 99, 1871.
≡ *Agaricus volvaceus* Bull.:Fr. 1786.

INDEX TO KUMMER'S *DER FÜHRER IN DIE PILZKUNDE*

This index has been compiled directly from Kummer's 1871 text, and includes all genera, species, and varieties mentioned in his Introduction (*Einleitung*, pp. 1–12) and genus and species keys. Taxa that Kummer characterised as "Abart" have been interpreted as varieties. Kummer supplied no authorities; these have been added from the literature. Typographic, orthographic, and grammatical errors, including those corrected by Kummer himself (*Druckfehler*, p. 146), have been annotated and corrected, with cross-referenced entries for both the erroneous and corrected spellings. (N.B. These corrections apply specifically to errors in Kummer's text; the same errors may, or may not, occur in protologues and recombinations published by other authors.)

In addition, all species and varieties are cross-referenced to previous, major European mycological publications with which, presumably, Kummer would have been acquainted. These publications are abbreviated as:

DKF: Rabenhorst, G.L. 1844. Deutschlands Kryptogamen-Flora, Pilze. Leipzig.
EF1: Fries, E.M. 1828. Elenchus fungorum, vol. 1. Greifswald.
EF2: Fries, E.M. 1828. Elenchus fungorum, vol. 2. Greifswald.
ESM: Fries, E.M. 1838. Epicrisis systematis mycologici. Uppsala.
Ind: Fries, E.M. 1832. Systema mycologicum, index alphabeticus. Greifswald.
MH1: Fries, E.M. 1854–57. Monographia hymenomycetum Sueciae, vol. 1. Uppsala.
MH2: Fries, E.M. 1851–63. Monographia hymenomycetum Sueciae, vol. 2. Uppsala.
SM1: Fries, E.M. 1821. Systema mycologicum, vol. 1. Lund.
SM2: Fries, E.M. 1822–23. Systema mycologicum, vol. 2. Lund.
SM3: Fries, E.M. 1829–32. Systema mycologicum, vol. 3,. Greifswald.
SVS: Fries, E.M. 1849. Summa vegetabilium Scandinaviae, sectio posterior. Uppsala.

Cross-references that are enclosed in parentheses (e.g. "(*Ind*:5)" under "*acicula* (Schaeff.) P.Kumm., *Mycena*", below) indicate that the cited page refers to the taxon only in synonymy.

For annotations on the names attributed to Kummer ("P.Kumm."), refer to NOMENCLATURAL NOVELTIES IN KUMMER'S *DER FÜHRER IN DIE PILZKUNDE*, above.

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* ?= *Cortinarius saniosus* sensu P.Kumm., non Fr. [fide E.Horak (pers. comm.)]		
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* the description suggests that Kummer (and Rabenhorst) misapplied Fries's name [cf. *Flammula saniosa*]		
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* nom. illegit., non *Boletus spadiceus* Krombh. 1836.		
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theiogalus (Bull.:Fr.) P.Kumm., *Galorrheus* [as "*thejogalus*"]	127	*SM1*:71; *ESM*:342; *DKF*:549; *MH2*:170
thejogalus [sic], *Galorrheus* – See *theiogalus, Galorrheus*		
Thelebolus Tode:Fr.	15 (30)	
Thelephora Ehrh. ex Willd.:Fr.	17 (43)	
thephroleucum [sic], *Limacium* – See *tephroleucum, Limacium*		
tigrina (Bull.:Fr.) P.Kumm., *Clitocybe* [as "*Clitocybe (Omphalia) figrina*"]	121 (146)	*SM1*:176; *ESM*:389; *DKF*:518; *MH2*:233
tigrinum P.Kumm., *Tricholoma*	131	(*SM1*:53); *ESM*:45; *DKF*:556
tithymalinus (Scop.:Fr.) P.Kumm., *Galorrheus*	129	*SM1*:71; *ESM*:346; *DKF*:547; *MH2*:179
titubans (Bull.:Fr.) Fr., *Bolbitius*	69	*SM1*:304; *ESM*:254; *DKF*:460; *MH1*:471
todei (Fr.:Fr.) Fr., *Typhula*	35	*SM1*:494; *ESM*:586; *DKF*:317; *MH2*:266
togularis (Bull. ex Pers.:Fr.) P.Kumm., *Pholiota*	85	*SM1*:241; *ESM*:161; *DKF*:488; *MH1*:306
tomentosum L.:Fr., *Hydnum*	51	*SM1*:405; *ESM*:510; *DKF*:408; *MH2*:258
tomentosum Fr., *Radulum*	49	*ESM*:525; *DKF*:401; *MH2*:259
tomentosus (J.Otto) P.Kumm., *Galorrheus*	125	(*SM1*:63; *ESM*:334); *DKF*:548
torminosus (Schaeff.:Fr.) P.Kumm., *Galorrheus*	125	*SM1*:63; *ESM*:334; *DKF*:553; *MH2*:153
tornata (Fr.:Fr.) P.Kumm., *Clitocybe*	122	*SM1*:91; *ESM*:62; *DKF*:541; *MH1*:110
torpens (Fr.:Fr.) P.Kumm., *Psathyra*	70	*SM1*:299; *ESM*:231; *MH1*:438
torquata (Fr.:Fr.) P.Kumm., *Mycena*	108	*SM1*:153; *ESM*:382; *DKF*:522; *MH2*:228
torvus, Cortinarius – See *umbrinus, Cortinarius*		

Taxon	**Page(s)**	**Earlier references**
trabea (Pers.:Fr.) Fr., *Daedalea*	53	*SM1*:335; *ESM*:406; *DKF*:443
trabeus Rostk.:Fr., *Polyporus*	58	*Ind*:149; *ESM*:454; *DKF*:428; *MH2*:252
traganus (Fr.:Fr.) Fr., *Cortinarius*	89	*SM1*:217; *ESM*:281; *DKF*:496; *MH2*:51
Trametes Fr. [sub *Polyporus*]	55	
Tremella Pers.:Fr.	16 (32)	
tremelloides (Vent.:Fr.) Pers., *Morchella*	48	*SM2*:10; *DKF*:383
tremellosus Schrad.:Fr., *Merulius*	53	*SM1*:327; *ESM*:500; *DKF*:414; *MH2*:256
tremulus (Schaeff.:Fr.) P.Kumm., *Pleurotus*	105	*SM1*:191; *ESM*:135; *DKF*:514; *MH1*:250
Tricholoma (Fr.:Fr.) Staude	(8) 25 (129)	
tricholoma (Alb. & Schwein.:Fr.) P.Kumm., *Flammula*	82	*SM1*:270; *ESM*:184; *DKF*:479; *MH1*:350
tricolor (Alb. & Schwein.:Fr.) P.Kumm., *Omphalia*	106	*SM1*:166; *ESM*:124; *DKF*:520; *MH1*:186
trigonophylla (Lasch:Fr.) P.Kumm., *Naucoria furfuracea* var. [as "*trigonophyllus*"]	77	*Ind*:45; *ESM*:200; *DKF*:474
trigonophyllus [sic], *Naucoria furfuracea* var. – See *trigonophylla*, *Naucoria furfuracea* var.		
triqueter (Alb. & Schwein.) Fr., *Polyporus*	56	(*SM1*:363); *ESM*:474; *DKF*:421; *MH2*:254
trivialis (Fr.:Fr.) P.Kumm., *Galorrheus*	127	*SM1*:65; *ESM*:337; *DKF*:552; *MH2*:160
truncata Fr.:Fr., *Exidia*	33	*SM2*:224; *ESM*:591; *DKF*:313; *SVS*:340
truncatum (Schaeff.) P.Kumm., *Hebeloma*	80	(*SM1*:225); *ESM*:181; *DKF*:480; *MH1*:331
tubaeformis (Bull.:Fr.) Fr., *Cantharellus*	103	*SM1*:319; *ESM*:366; *DKF*:446; *MH2*:208
Tuber F.H.Wigg.:Fr.	13 (27)	
tuberculosa (Schaeff.:Fr.) P.Kumm., *Pholiota*	83	*SM1*:244; *ESM*:167; *DKF*:485; *MH1*:316
tuberosa (Bull.:Fr.) P.Kumm., *Collybia*	(112) 116	*SM1*:133; *ESM*:90; *DKF*:535; *MH1*:160
tuberosa (Hedw.:Fr.) Bull., *Peziza*	42	*SM2*:58; *DKF*:371; *SVS*:348
Tulostoma Pers.:Pers.	15 (30)	
tunicata Fr., *Bovista*	32	*SM3*:25; *DKF*:301; *SVS*:442
turbinatum (Bull.:Fr.) P.Kumm., *Myxacium*	92	*SM1*:225; *ESM*:266; *DKF*:500; *MH2*:22
turgidum Fr., *Polysaccum*	29	*DKF*:295
turpis (Weinm.) P.Kumm., *Galorrheus*	125	*ESM*:335; *DKF*:553; *MH2*:154
Typhula (Pers.:Fr.) Fr.	16 (35)	

U

Taxon	**Page(s)**	**Earlier references**
udus (Pers.:Fr.) P.Kumm., *Coprinarius*	69	*SM1*:292; *ESM*:228; *DKF*:463; *MH1*:430
ulmarius (Bull.:Fr.) P.Kumm., *Pleurotus*	105	*SM1*:186; *ESM*:130; *DKF*:517; *MH1*:239
umbellatus (Pers.:Fr.) Fr., *Polyporus*	60	*SM1*:354; *ESM*:446; *DKF*:431; *MH2*:252
umbellifera (L.:Fr.) P.Kumm., *Omphalia*	107	(*SM1*:165); *EF1*:22; *ESM*:124; *DKF*:520; *MH1*:187
umbilicata P.Kumm., *Clitocybe* [as "*ambilicata*"]	123 (146)	(*SM1*:125); *ESM*:121; *DKF*:521; *MH1*:179
umbonatus (J.F.Gmel.:Fr.) Fr., *Cantharellus*	103	*SM1*:317; *ESM*:365; *DKF*:446; *MH2*:207
umbrina Fr., *Reticularia*	28	*SM3*:87; *DKF*:255; *SVS*:449
umbrinus (Pers.) P.Kumm., *Cortinarius* [as "*umbrinus (torvus)*"]	88	(*SM1*:211; *ESM*:293); *DKF*:493
umbrinus (Pers.) P.Kumm., *Galorrheus*	129	(*SM1*:74); *ESM*:339; *DKF*:551; *MH2*:164
umbrosus (Pers.:Fr.) P.Kumm., *Pluteus*	98	*SM1*:200; *ESM*:140; *DKF*:511; *MH1*:263
undulata (Jungh.:Fr.) P.Kumm., *Naucoria*	77	*Ind*:46; *ESM*:199 as "*undulosus*"; *DKF*:474 as "*undulosus*"
unguicularis (Fr.:Fr.) P.Kumm., *Pleurotus*	104	*EF1*:24; *ESM*:137; *DKF*:514; *MH1*:256
unicolor (Bull.:Fr.) Fr., *Daedalea*	53	*SM1*:336; *ESM*:494; *DKF*:414; *MH2*:256
unicolor Fr.:Fr., *Tremella*	32	*SM2*:218; *ESM*:589; *DKF*:310
urens (Bull.:Fr.) P.Kumm., *Collybia*	115	*SM1*:232; *ESM*:373; *DKF*:535; *MH2*:216
urens P.Kumm., *Tricholoma*	131	

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ustale (Fr.:Fr.) P.Kumm., *Tricholoma*	130	*SM1*:37; *ESM*:29; *DKF*:562; *MH1*:57
utriforme Bull.:Pers., *Lycoperdon*	31	*SM3*:25 as "*uteriformis*"; *DKF*:298
uvidus (Fr.:Fr.) P.Kumm., *Galorrheus*	126	*SM1*:66; *ESM*:338; *DKF*:551; *MH2*:162
V		
vaccinum (Schaeff.:Fr.) P.Kumm., *Tricholoma*	133	*SM1*:42; *ESM*:33; *DKF*:560; *MH1*:65
vaginata (Bull.:Fr.) Lam., *Amanita*	137	*SM1*:14; *ESM*:11; *DKF*:575; *MH1*:2
vaillantii (Fr.:Fr.) Fr., *Marasmius*	113	*SM1*:136; *ESM*:380; *DKF*:530; *MH2*:223
vaillantii (DC.:Fr.) Fr., *Polyporus*	54	*SM1*:383; *ESM*:487; *DKF*:416; *MH2*:255
vaporaria (Pers.) P.Kumm., *Psalliota campestris* var. [as "*vaporarius*"]	73	*ESM*:213; *DKF*:469
vaporarium (Pers.) Becker, *Aethalium*	27	(*SM3*:93); *DKF*:253; *SVS*:449
vaporarius (Pers.:Fr.) Fr., *Polyporus*	54	*SM1*:382; *ESM*:487; *DKF*:416; *MH2*:255
vaporarius [sic], *Psalliota campestris* var. – See *vaporaria*, *Psalliota campestris* var.		
variabilis (Pers.:Fr.) P.Kumm., *Crepidotus*	74	*SM1*:275; *ESM*:211; *DKF*:470; *MH1*:401
variecolor (Pers.:Fr.) P.Kumm., *Pholiota*	85	*SM1*:222; *ESM*:259; *DKF*:502; *MH2*:9
variegata (Fr.:Fr.) Fr., *Daedalea*	53	*SM1*:337; *ESM*:406; *DKF*:443; *MH2*:246
variegata [sic], *Tricholoma rutilans* var. – See *variegatum*, *Tricholoma rutilans* var.		
variegatum (Rabenh.) P.Kumm., *Tricholoma rutilans* var. [as "*variegata*"]	133	(*SM1*:53); *ESM*:31; *DKF*:561; *MH1*:60
variegatus Sw.:Fr., *Boletus*	65	*SM1*:388; *ESM*:413; *DKF*:440; *MH2*:249
varius (Pers.:Fr.) Fr., *Polyporus*	61	*SM1*:352; *ESM*:440; *DKF*:431; *MH2*:251
vellerea [sic], *Galorrheus* – See *vellereus*, *Galorrheus*		
vellereus (Fr.:Fr.) P.Kumm., *Galorrheus* [as "*vellerea*"]	125	*SM1*:76; *ESM*:340; *DKF*:550; *MH2*:167
velutina DC.:Fr., *Thelephora*	44	*EF1*:203; *ESM*:561; *DKF*:390; *MH2*:262
velutinum Fr.:Fr., *Hydnum*	51	*SM1*:404; *ESM*:508; *DKF*:409; *MH2*:257
velutinum (Pers.:Fr.) P.Kumm., *Hypholoma*	72	*SM1*:288; *ESM*:223; *DKF*:465; *MH1*:424
velutinus (Pers.:Fr.) Fr., *Polyporus*	56	*SM1*:368; *ESM*:478; *DKF*:420; *MH2*:254
velutipes (Curtis:Fr.) P.Kumm., *Collybia*	116	*SM1*:119; *ESM*:86; *DKF*:536; *MH1*:154
ventricosa (Bull.:Fr.) P.Kumm., *Psilocybe*	71	*SM1*:294; *ESM*:91; *DKF*:464
verna (Bull.:Fr.) Lam., *Amanita*	138	*SM1*:13; *ESM*:4; *DKF*:578; (*MH1*:4)
verrucosum (Bull.:Pers.) Pers., *Scleroderma*	29	*SM3*:49; *DKF*:296; *SVS*:444
versicolor (L.:Fr.) Fr., *Polyporus*	56	*SM1*:368; *ESM*:478; *DKF*:420; *MH2*:254
vesca Fr., *Russula*	102	*ESM*:352; *DKF*:451; *MH2*:193
vesiculosa Bull.:Fr., *Peziza*	42	*SM2*:52; *DKF*:373; *SVS*:349
vibratile (Fr.:Fr.) P.Kumm., *Myxacium*	93	*SM1*:227; *ESM*:277; *DKF*:498; *MH2*:43
vietus (Fr.:Fr.) P.Kumm., *Galorrheus*	126	*SM1*:66; *ESM*:344; *DKF*:548; *MH2*:171
villosa (Schumach.:Fr.) Fr., *Typhula*	35	*SM1*:495; *ESM*:585; *DKF*:318; *MH2*:266
vinacea (Scop.) P.Kumm., *Nolanea*	95	*ESM*:157; *DKF*:504; *MH1*:295
violaceocinereus (Pers.:Fr.) Fr., *Cortinarius*	90	*SM1*:217; *ESM*:279; *DKF*:497; (*MH2*:48 as "*cinereoviolaceus*")
violaceofulvens (Batsch:Fr.) P.Kumm., *Crepidotus* [as "*violaceofulvus*"]	74	*SM1*:276; *ESM*:212; *DKF*:470; (*MH1*:402)
violaceofulvus [sic], *Crepidotus* – See *violaceofulvens*, *Crepidotus*		
violaceum (Pers.) Spreng., *Aethalium*	27	(*SM3*:93); *DKF*:254
violaceus (L.:Fr.) Fr., *Cortinarius*	90	*SM1*:217; *ESM*:279; *DKF*:497; *MH2*:46
violaceus Fr.:Fr., *Polyporus*	55	*SM1*:379; *ESM*:484; *DKF*:418; *MH2*:254
violascens (J.Otto:Fr.) P.Kumm., *Galorrheus*	127	*SM1*:75; *ESM*:342; *DKF*:549; *MH2*:165
violascens Alb. & Schwein.:Fr., *Hydnum* [as "*violescens*"]	52	*SM1*:401; *ESM*:507; *DKF*:410; *MH2*:257
violescens [sic], *Hydnum* – See *violascens*, *Hydnum*		
virescens (Schaeff.) Fr., *Russula*	101	(*SM1*:57); *ESM*:355; *DKF*:450; *MH2*:190

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virgatum (Fr.:Fr.) P.Kumm., *Tricholoma*	134	*SM1*:48; *ESM*:39; *DKF*:558; *MH1*:75
virgineus (Wulfen:Fr.) P.Kumm., *Camarophyllus*	117	*SM1*:100; *ESM*:327; *DKF*:566; *MH2*:133
viride (J.F.Gmel.:Fr.) Pers., *Geoglossum*	39	*SM1*:489; *ESM*:582; *DKF*:329
viscidus (L.) P.Kumm., *Gomphus*	93	(*SM1*:315); *ESM*:319; *DKF*:453; *MH2*:150
viscosa (Pers.:Fr.) Fr., *Calocera*	36	*SM1*:486; *ESM*:581; *DKF*:319; *MH2*:266
vitellina (Fr.) Rabenh.*, *Russula*	101	(*SM1*:56); *ESM*:363; *DKF*:447
* basionym: *Russula nauseosa* subsp. *vitellina* Fr. 1838 [≡ nom. nov. for *Agaricus vitellinus* Pers. 1801, p. 422, nom. illegit., non Pers.:Fr. 1801, p. 402].		
vitellinus (Pers.:Fr.) Fr., *Bolbitius*	69	*SM1*:303; *ESM*:254; *DKF*:461; *MH1*:470
vitreus (Pers.:Fr.) Fr., *Polyporus*	54	*SM1*:381; *ESM*:485; *DKF*:417; *MH2*:254
vittaeformis [sic], *Galera* – See *vittiformis, Galera*		
vittiformis (Fr.) P.Kumm., *Galera* [as "*vittaeformis*"]	75	*ESM*:207; *DKF*:472; *MH1*:393
volemus (Fr.:Fr.) P.Kumm., *Galorrheus*	127 (128)	*SM1*:69; *ESM*:344; *DKF*:548; *MH2*:178
volvacea (Bull.:Fr.) P.Kumm., *Volvaria*	99	*SM1*:278; *ESM*:138; *DKF*:512; *MH1*:260
Volvaria (Fr.:Fr.) P.Kumm.	(7 as "*Vulvaria*") 23 (99)	
vulgare Link, *Hypoxylon*	34	*DKF*:222
vulgare Hornem., *Scleroderma*	(10) 28	*SM3*:46; *DKF*:295; *SVS*:444
vulgaris (Pers.:Fr.) P.Kumm., *Mycena*	108	*SM1*:156; *ESM*:116; *DKF*:523; *MH1*:228
vulgaris Fr.:Fr., *Polyporus*	54	*SM1*:381; *ESM*:485; *DKF*:417; *MH2*:255
Vulvaria [sic] – See *Volvaria*		
X		
xerampelina (Schaeff.) Fr., *Russula*	100	(*SM1*:54); *ESM*:356; *DKF*:450; *MH2*:192
Z		
zephirus (Fr.:Fr.) P.Kumm., *Mycena* [as "*zephyrus*"]	110	*SM1*:147; *ESM*:102; *DKF*:528; *MH1*:202
zephyrus [sic], *Mycena* – See *zephirus, Mycena*		
zonarius (Bull.) P.Kumm., *Galorrheus*	127	(*SM1*:74); *ESM*:336; *DKF*:552; *MH2*:158
zonatum Batsch, *Hydnum*	51	(*SM1*:405); *ESM*:509; *DKF*:408; *MH2*:257
zonatus (Nees:Fr.) Fr., *Polyporus*	56	*SM1*:368; *ESM*:478; *DKF*:420; *MH2*:254

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THE TAXONOMIC POSITION OF RHIZOPOGON MELANOGASTROIDES (BOLETALES)

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Abstract

Molecular data confirm the exclusion of *Rhizopogon melanogastroides* from the genus *Rhizopogon*. These data, as well as the ectomycorrhiza features do not confirm the inclusion of this taxon in the genus *Melanogaster*.

Key words: ectomycorrhizae, rDNA ITS, chemical, *Rhizopogon*, Boletales

INTRODUCTION

LANGE (1957) described a new species *Rhizopogon melanogastroides* M. Lange, based on a single, dried specimen collected by F. Petrak in Moravia in 1928 (MARTÍN, 1996). The microscopic characters, such as the thick-walled spores with a truncate base and a large basal chamber clearly delimited the species. However, the macroscopic characters were not well defined and he mentions that new studies would be required using fresh material. According to this author and TRAPPE (1975), from the spore shape alone, this species would be a transition to the genus *Melanogaster*, but the persistent hymenium and the open-chambered gleba suggest including this species in the genus *Rhizopogon*. After the revision of the type material deposited at the Copenhagen (C) herbarium which demonstrated the presence of an hymenium and the absence of clamp connections, MARTÍN (1996) accepted this taxon in the genus *Rhizopogon* and not *Melanogaster*.

In 1997, one of the authors (SR) had the chance to collect fresh basidiomes of *Rhizopogon melanogastroides* under *Pinus mugo* Turra in Germany. This collection gave the opportunity to check the macroscopic characters (described here) and study the tuberculate ramificed *Pinus* ectomycorrhiza collected close to the basidiomes (RAIDL, 1998; RAIDL et al., 1998).

The purpose of this presentation is to delimate the taxonomic position of *Rhizopogon melanogastroides*, using not only morphological and anatomical characters, but also chemical and molecular methods.

MATERIAL AND METHODS

Material examined: Germany, Bavaria, Oberbayern, district Bad Tölz-Wolfratshausen, in the valley of the river Isar between Vorderriß and Wallgau, ca. 20 m from the river bank, 47° 33′north and 11° 24′west, 795 m elev., under *Pinus mugo* in loose stand of spruce (*Picea abies* (L.) Karst.) and pine (*Pinus sylvestris* L. and *Pinus mugo*) mixed with shrubs (Erico-Pinetum), 1/X/1997, leg. et det. S. Raidl, SR 409, fruitbodies in M, dupl. in MA-47690 (HOLMGREN et. al 1999).

Chemical methods: The ethanol extractions (MARTÍN & SÁNCHEZ-CUIXART, 1996) were developed (TLC) in the solvent system benzene: ethyl formate: formic acid (10:5:3) in standard Brinkman tanks on 20 x 20 cm Merck pre-coated Silica Gel F254 plates. These extractions were also analyzed by HPLC. The HPLC run was done according to SCHMIDT (1990). The column was stainless steel (Knauer, Berlin), 250 x 4 mm in diameter, filled with Nucleosil® C18, 5 µm spherical particles (Macherey & Nagel, Düren). The composition of the eluents was (A) H_2O/CH_3OH (9/1, v/v) with 0.1-0.5 % (vol.) of CF_3CO_2H and (B) CH_3OH; all reagents were of highest analytical purity. The flow rate was 1ml min^{-1}. The gradient used was 100 % A at the start, reaching B after 55 min. For detection of the pigments a photodiodearray detector (Waters, Eschborn), online with the HPLC-column was used; data acquisition was between 230 and 599 nm.

Molecular methods: A small quantity (less that 10 mg) of each collection was subjected to molecular analysis of the internal transcribed spacer regions of rDNA (ITS1 and ITS2), including the 5.8S. Total DNA was isolated using E.Z.N.A. Fungal MiniPrep Kit (Omega-Biotech, Doraville, USA) as described in MARTÍN & GARCÍA-FIGUERES (1999). Primer pair ITS1F and ITS4 was used to obtain amplifications of both ITS regions, including the 5.8S of the ribosomal RNA gene cluster and small flanking parts of the SSU and LSU genes; primers were described in WHITE et al. (1990). Amplifications were done using Ready-to-Go® PCR Beads (Amersham-Pharmacia Biotech) as mentioned in WINKA et al. (1998). Results of amplifications were assayed from 5µl aliquots by gel electrophoresis of 1% ME-Agarose (Seakem, FMC Bioproducts). Amplification products were cleaned using the E.Z.N.A. Clean kit (Omega Biotech.) and both strands were sequenced separately using primers ITS1F and ITS4 at the Authomatic Sequencing Service (CIB-CSIC, Madrid). Sequence Navigator™ Sequence Comparison software (Perkin Elmer) was used to identify the consensus sequence from the two strands of each ITS region. The new consensus sequence has been logged in the EMBL database with the Accesion Numbers AJ419206. Sequences obtained in this study were compared with homologous sequences from 42 Boletales (MARTÍN & TELLERÍA unpublished): *Alpova* sp. (AJ419181); *Boletus edulis* Bull.: Fr. (AJ419182); *Boletinellus exiguus* (Singer & Digilio) Watling (AJ419183); *Boletinellus exiguus* (AJ419185); *Boletus fragrans* Vitt. (AJ419186); *Boletus impolitus* Fr. (AJ419187); *Boletus erythropus* (Fr.: Fr.) Krombh. (AJ419188) *Boletus rhodoxanthus* (Krombh.) Kallenb. (AJ419189); *Boletus pinicola* (Vitt.) Vent. (AJ419190); *Boletus luridus* Schaeff.: Fr. (AJ419191); *Boletinellus rompelli* (Pat. & Rick.) Watling (AJ419192); *Chalciporus piperatus* (Bull.: Fr.) Bataille (AJ419193); *Coniophora arida* (Fr.) P. Karst. (AJ419195); *Coniophora arida* (AJ419196); *Coniophora prasinoides* Boud. (AJ419197); *Coniophora puteana* (Schumach.: Fr.) P. Karst. (AJ419198); *Coniophora puteana* (AJ419199); *Gomphidius roseus* L.: Fr. (AJ419200); *Hygrophoropsis aurantiaca* (Wulf.: Fr.) Mre. (AJ419201); *Hygrophoropsis* *aurantiaca* (AJ419202); *Melanogaster broomeianus* Berk. ex Tul. & Tul. (AJ419203); *Melanogaster variegatus* (Vitt.) Tul. & Tul. (AJ419204); *Boletinus cavipes* (Kotz.: Fr.) Kalchbrenner (AJ419205); *Rhizopogon corsicus* V. Demoulin & B. Moyersoen (AJ419207 ITS1); *Rhizopogon ellenae* A. H. Smith (AJ419208); *Rhizopogon roseolus* (Corda) Th. M. Fr. (AJ419209); *Rhizopogon roseolus* (AJ419210); *Rhizopogon roseolus* (AJ419211); *Rhizopogon subsalmoneus* A. H. Smith (AJ419212 ITS1); *Serpula himantioides* (Fr.: Fr.) Karst. (AJ419213); *Leucogyrophana pinastri* (Fr.) Ginns & Weresub (AJ419214); *Suillus bovinus* (L.: Fr.) Kuntze (AJ419215); *Suillus bellinii* (Inzenga) Watling (AJ419216); *Suillus cothurnatus* Singer (AJ419217); *Suillus cothurnatus* (AJ419218); *Suillus luteus* (L.: Fr.) S. F. Gray (AJ419219); *Suillus tridentinus* (Bres.) Singer (AJ419220); *Xerocomus armeniacus* (Quél.) Quél. (AJ419221); *Xerocomus badius* (Fr.: Fr.) Gilbert (AJ419222); *Xerocomus chrysenteron* (Bull.) Quél. (AJ419223), *Boletus erythropus* (AJ496595). As well as the 5.8S and ITS2 sequences of *R. corsicus* (AF115833) and *R. subsalmoneus* (AF115845) included in JOHANNESON & MARTÍN (1999) and sequences of *Boletus calopus* Pers. (AJ296293), *Boletus lupinus* Fr. (AJ296294) and *Sullis variegatus* (Swartz: Fr.) Kuntze (AF231914) published in previous papers (CALONGE & MARTÍN, 2000; MARTÍN & MORENO, 2001). Other sequences included in this study were obtained from the GenBank (EMBL): *Boletus mirabilis* (Murill) Murill (AF335451), *Coniophora puteana* (AF249503), *Gomphidius roseus* (AF205638M) and *Truncocolumella citrina* Zeller (L54097). The sequence of *Rhizopogon luteolus* Fr. & Nordholm (JMT 22516) was kindly sent by Lisa Grubisha (Oregon Univ.) and that of *R. vinicolor* A. H. Smith (AF263929) by Annette Kretzer (Oregon University).

SEQAPP software for multiple sequences was used to search for the best alignment. Alignment gaps were marked "-" and unresolved nucleotides or unknown sequences were indicated with "N". The polarity of characters was assessed with outgroup comparison, using *Ramaria botrytis* (Pers.) Ricken (AJ292294, DÄNIELS et al. , unpublished) as outgroup.

The data matrix was analysed using the PAUP 4.0b* software package (SWOFFORD, 1998), under parsimony (MP) and maximum likelihood (ML). In the MP analysis heuristic algorithm was employed, in the ML analysis (FELSENTEIN, 1981) heuristic search and the HKY model of DNA substitution (KISHINO & HASEGAWA, 1989). Branch robustness was estimated by fast-stepwise-addition bootstrap analysis (FELSENTEIN, 1985) of 10000 replicates.

RESULTS AND DISCUSSION

Morphology.- The description is based on fresh basidiomes, two very immature and three mature ones. **Basidiomes** very compact (Fig. 1), the youngest subglobose to oval; the others more oval to elongated, somewhat irregular, measurements of the biggest mature basidiome: 17 mm long, 10 mm broad and up to 8 mm high, surface smooth without attached mycelium, but with rhizomorphal strands at the very base (leading to the ectomycorrhizae). **Peridium** thin, colour when young outside creamy whitish to dull yellowish and becoming brown a while after touching; mature basidiomes more dark dull yellow to pale brown, in some parts of mature basidiomes black gleba shining through (this may fit with Lange's observation of "a few chambers even opening through the peridium"), mature basidiomes blueing immediately after touching (during digging them out - pale to grey blueish, a kind of dirty blue), after a while this blue colour disappears and the basidiome surface becomes more dark reddish to woody brown. In the dried specimen peridium now dull dark brown without any red and the gleba appears nearly wood brown, as Lange mentioned for Petrak's specimen. **Gleba** firm and irregularly chambered, in young basidiomes creamy whitish to yellowish like peridium, in mature basidiomes deep black and shining through peridia, in dried specimen of mature basidiomes dark brown to woody brown. **Smell** of young basidiomes unspecific, of mature basidiomes distinct sweetish resembling

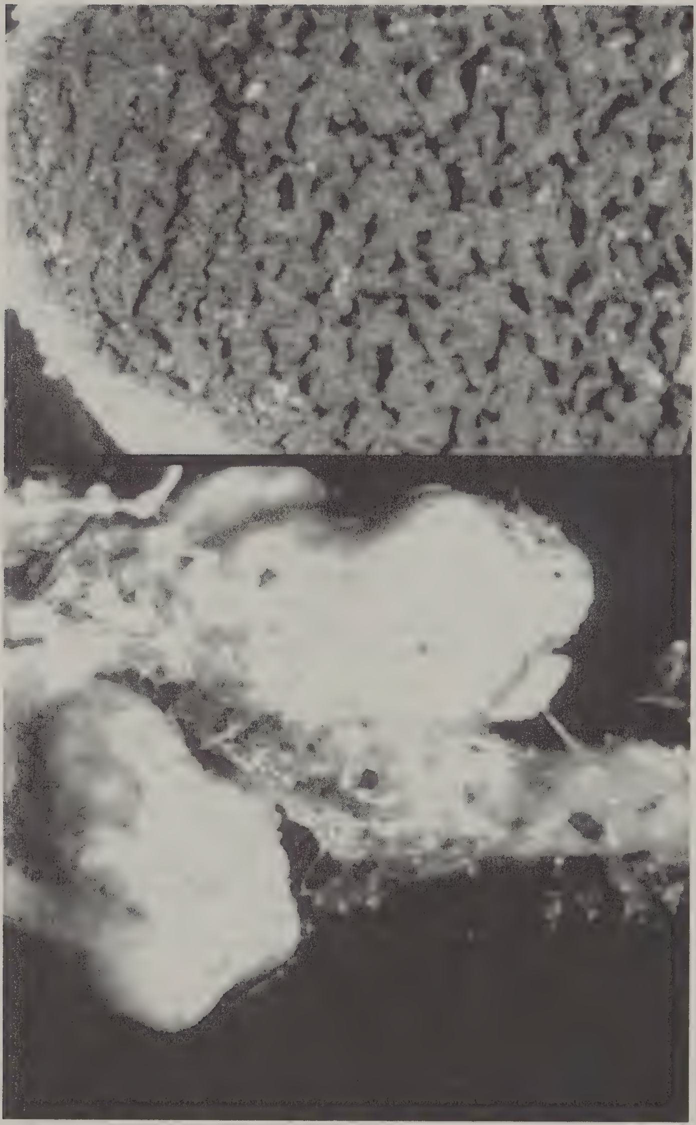

Fig. 1 *Rhizopogon melanogastroides.* Basidiome (above) and tuberculate ectomycorrhizae (below).

fruit - very characteristic like cherries in alcohol (the smell of "mon cheri" which is bitter chocolate filled with a cherry and alcohol). **Taste** not tested.

Ectomycorrhiza.- As mentioned in RAIDL et al. (1998) the ectomycorrhizae formed by *Rhizopogon melanogastroides* and *Pinus mugo* show a number of features not seen in any of the *Rhizopogon* ectomycorrhizae studied so far in detail (ZAK, 1971, UHL, 1988, AGERER et al., 1996, RAIDL & AGERER, 1998, JAKUCS et al., 1998). Most of the *Rhizopogon* ectomycorrhizae have the following characters: coralloid-tuberculate ramification systems (a feature determined by the host genus *Pinus*, PILLUKAT & AGERER, 1992), a plectenchymatous mantle, highly differentiated and regularly branching rhizomorphs with central vessel hyphae (so-called boletoid type, being typical for most members of the Boletales, according to AGERER, 1999) and a distinct rind of relatively thin hyphae forming the surface. However, *R. melanogatroides* ectomycorrhizae are tuberculate (Fig. 1), the mantle is plectenchymatous throughout with the outermost layer formed of loosely arranged hyphae which are densely covered by crystals and soil particles. Very characteristic is a deep yellow gelatinous matrix covering the outer mantle layer and hyphae with globular inflations rising from the mantle surface into this matrix. Until now there are no mycorrhizae described for the genus *Rhizopogon* and the genus *Melanogaster* (only *Melanogaster ambiguus* (Vitt.) Tul. & Tul., PARLADÉ et al., 1996) which show a deep yellow matrix and the characteristic bubble cells in the outer mantle layer found in mycorrhizae of *R. melanogastroides.*

Chemical analysis.- From the two small fragments of *R. melanogastroides* analyzed different compounds were extracted; one eluted after 25 min with a UV spectrum similar to variegatic rubin and an undescribed compound that eluted after 15 min similar to L-DOPA. From 33 *Rhizopogon* collections analyzed by TLC and HPLC at München University (MARTÍN & TELLERÍA, unpublished), several different compounds were extracted: mainly, xerocomic acid, variegatic rubin; moreover undescribed compounds that eluted after 7, 15 and 19 minutes with a UV spectrum similar to L-DOPA. From two *Melanogaster* collections involutin and chamonixin were eluted after 7 and 8 minutes, as well as a compound eluted after 14 minutes with a UV spectrum related to gyroporin.

Molecular analysis.- The total aligned sequences ITS1-1 and ITS-2, including the 5.8S gene, were 1085 base pairs (bp) long, 570 were eliminated due to the ambiguities during the alignment and 250 were parsimony informative. Maximum Parsimony (MP) analysis under heuristic search gave 8 most parsimonious trees with a length of 1370 steps, a consistency index (CI) of 0.4664 and a retention index (RI) of 0.5336. Fig. 2 shows the strict consensus tree. This tree showed the same topology as the Maximum Likelihood (ML) tree (not included here). The present data show that *Rhizopogon melanogastroides* is an independent taxon, not closely related to *Rhizopogon*, nor to *Melanogaster*. This taxon appears as the sister group of the other genera included in the Boletales.

Although chemical data have not proven too useful, since the pigments found in *Rhizopogon melanogastroides* are very frequent in the Boletales (GILL & STEGLICH, 1987), both anatomical ectomycorrhizal characters as well as molecular data support splitting *Rhizopogon melanogastroides* from the genus *Rhizopogon.* In our molecular data set the tropical Boletales are not included; thus, before designating a new genus for the taxon subject of this study we will await more complete information.

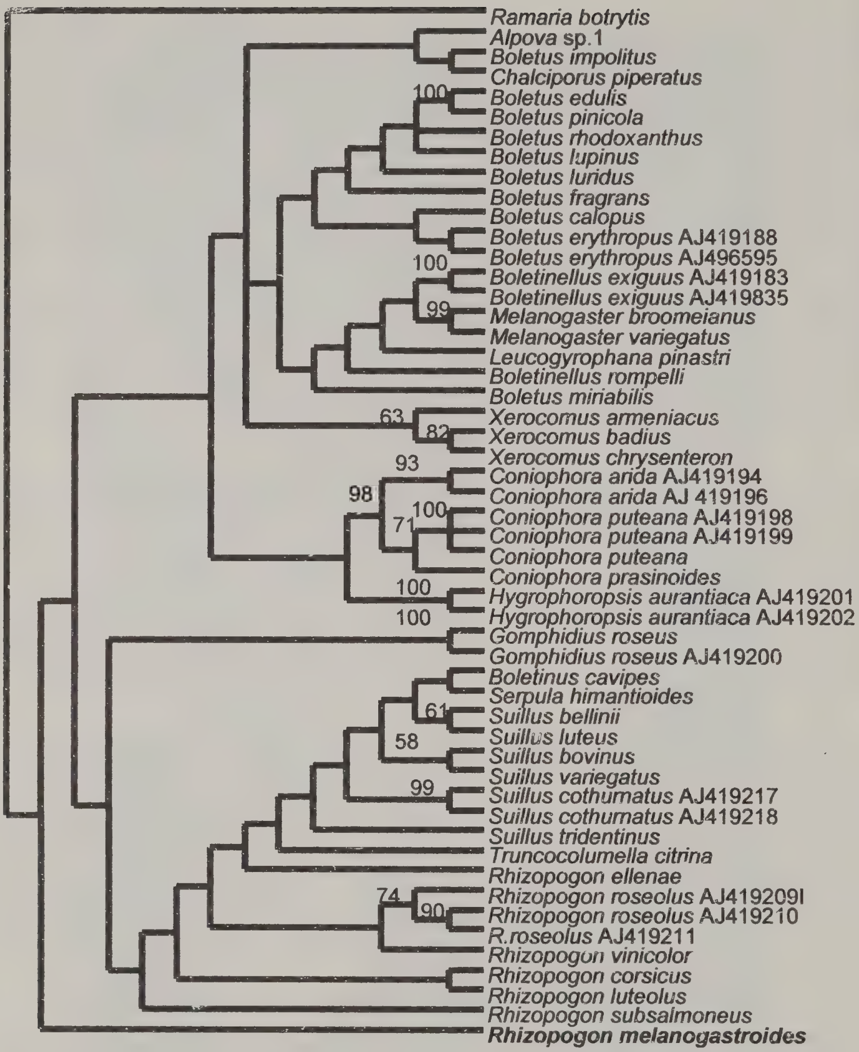
Ramaria botrytis
Alpova sp.1
Boletus impolitus
Chalciporus piperatus
100
Boletus edulis
Boletus pinicola
Boletus rhodoxanthus
Boletus lupinus
Boletus luridus
Boletus fragrans
Boletus calopus
Boletus erythropus AJ419188
Boletus erythropus AJ496595
100
Boletinellus exiguus AJ419183
Boletinellus exiguus AJ419835
99
Melanogaster broomeianus
Melanogaster variegatus
Leucogyrophana pinastri
Boletinellus rompelli
Boletus miriabilis
63
Xerocomus armeniacus
82
Xerocomus badius
Xerocomus chrysenteron
93
Coniophora arida AJ419194
98
Coniophora arida AJ 419196
100
Coniophora puteana AJ419198
71
Coniophora puteana AJ419199
Coniophora puteana
Coniophora prasinoides
100
Hygrophoropsis aurantiaca AJ419201
100
Hygrophoropsis aurantiaca AJ419202
Gomphidius roseus
Gomphidius roseus AJ419200
Boletinus cavipes
Serpula himantioides
61
Suillus bellinii
Suillus luteus
58
Suillus bovinus
Suillus variegatus
99
Suillus cothurnatus AJ419217
Suillus cothurnatus AJ419218
Suillus tridentinus
Truncocolumella citrina
Rhizopogon ellenae
74
Rhizopogon roseolus AJ419209I
90
Rhizopogon roseolus AJ419210
R.roseolus AJ419211
Rhizopogon vinicolor
Rhizopogon corsicus
Rhizopogon luteolus
Rhizopogon subsalmoneus
Rhizopogon melanogastroides

Fig. 2. Exhaustive search based on 250 parsimony-informative characters. Percentages from 10000 bootstrap replications are given on the branches. When more than one collection was studied, accesion numbers (EMBL) are indicated after the species name.

ACKNOWLEDGMENTS

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SOME RUSSULAS OF THE SUBSECTION URENTINAE

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ABSTRACT

Several species of *Russula* in subsection *Urentinae* section *Russula* are described. A new name, *Russula cinereovinosa* is assigned to *R. cinereopurpurea.* Illustrated descriptions are presented for *R. macropoda, R. maculata, R. tenuiceps* and three new species, *R. subtenuiceps, R. fastigiata* and *R. luteofolia.*

KEYWORDS

Basidiomycetes, Russulaceae, eastern North America, ectomycorrhizal, taxonomy.

INTRODUCTION

North American mycological literature contains few references to species of *Russula* in Singer's (1986) section *Russula,* subsection *Urentinae* which is equivalent to Romagnesi's (1967) section *Insidiosae*, subsections *Urentinae* and *Maculatinae.* The only descriptions detailed enough by present standards to permit identification with any degree of certainty were presented by Shaffer (1970) for *R. aurantiolutea* and *R. adulterina.* Over the years, my collections from eastern North America of red capped, ochre gilled, strongly acrid Russulas with a massed spore color of deep yellow-ochre were identified either as *R. tenuiceps* or as being in a *R. macropoda - R. maculata* complex. To determine their actual species designations I have recently studied these collections and compared them with reference herbarium material. Presented here are the results of these observations on the three species. Since the collections did not match the reference material or any other literature descriptions, three new species, *R. subtenuiceps, R. fastigiata* and *R. luteofolia* are described. Correct field identification of any of these six species is difficult and unlikely because of similarities in general physical appearance and the existence of many yet undescribed species in subsection *Maculatinae.* Also in this subsection, previously published, Fatto (2000), *R. cinereopurpurea* is renamed since this epithet has prior usage.

MATERIALS AND METHODS

Color terms and designations used in the following descriptions are cited from Maerz & Paul (1950), e.g., M&P 7L12, or from the ISCC-NBS system (Kelly & Judd, 1955), e.g., 54 brownish Orange. Otherwise, color names are the author's concept of general color hues. The massed spore color designated by a capital letter from A to H refers to the spore color code of Pearson (1950), or designated by a Roman numeral alphabetical combination, e.g., IVe, refers to Romagnesi's (1967) color code. Spores were examined mounted in Melzer's reagent, size determined in lateral view, with ornamentation excluded. Length to breadth ratio, Q, was determined by measurement of a minimum of 25 spores per specimen. The pileus was studied from tangential sections, initially inspected in 10% NH_4OH to observe any gelatinous matrix. Microscopic descriptions were made from sections mounted in 3% KOH. Sulfovanillin (SV) was used to evaluate reactivity of cystidial content. Illustrations were made with the aid of a drawing tube. Unless otherwise indicated, specimens studied are presently located in my personal herbarium.

TAXONOMY

Russula cinereovinosa Fatto, nom. nov.

Russula cinereopurpurea Fatto, Mycotaxon **75**: 268. 2000. non Krombholz, Natur. Abbild. Beschreib. Schwemma **9**: 12. pl. 66, f. 14, 15. 1845.

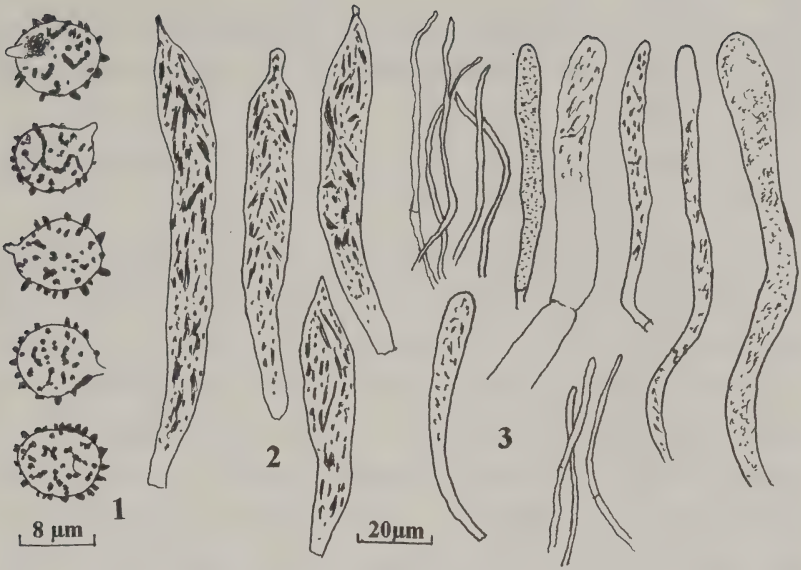
Since the epithet selected for this new species had previously been published by Krombholz, it is necessary to designate another name.

In addition to the previously cited Arizona collections made in the Chiricahua Mtns. at elevations above 6900 feet under ponderosa pine, a Colfax Co., New Mexico collection further extends the range and habitat of *R. cinereovinosa*. Fatto 666, 14 Aug 1992, was obtained at the North American Mycological Association (NAMA) foray at Angel Fire, NM in a fir-spruce habitat at about 9000 feet and had then been tentatively identified as *R. atroviolacea*.

Russula macropoda Singer, Bull. Soc. Mycol. Fr. 55: 277. 1939. Figs. 1-3

Pileus 5-7 cm broad, plane with a slightly depressed central area, margin weakly striate for 4 mm; cuticle separable less than 1/3 the radius, glabrous, shiny and viscid when moist, a clean bright red near M&P 3K11 marginally, spotted yellowish-orange near M&P 3D10 centrally; trama thin, firm-brittle, white, unchanging; odor none; taste slowly very acrid. **Lamellae** 3-4 mm broad at mid-radius, subacute in front, adnate, close, equal but with a few random forks and long lamellulae, brittle, ochraceous. **Stipe** 4-7 x 1-2 cm, equal, dry, glabrous, longitudinally rugulose, white or with pale pink areas, trama spongy-stuffed, unchanging.

Chemical reactions (stipe surface): SV weak purplish gray; 10% $FeSO_4$ pale salmon brown; 2% Phenol medium brown; formalin none; guaiac greenish-blue.



FIGS. 1-3. *Russula macropoda* (Singer V270). 1. Spores. 2. Hymenial cystidia. 3. Hyphal ends from pileus cuticle.

Spores ochraceous in mass, G (M&P 10G4) or IVc, (7.2-)8-9.6 x 6.4-7.2(-8) µm, average size 8.6 x 6.9 µm, Q=1.23, broadly elliptic to broadly obovate; ornamentation of amyloid warts 0.8-1.2 µm high, cylindric to narrowly conic, isolated, often catenulate or with a few fine connectives; suprahilar area a weakly amyloid patch. **Basidia** 36-48 x 10-14 µm, clavate, 4-sterigmate. **Hymenial cystidia** 44-104 x 9-14 µm, subcylindric, fusoid-clavate, apices subacute, few rounded, most mucronate or with a short finger like appendage, content strongly banded to granular, SV+, arising from subhymenium or outer edge of trama, embedded to projecting to 30 µm, common, margin homomorphous. **Subhymenium** 40-68 µm thick, pseudoparenchymatous, cells 8-14 µm wide at mid-lamella, lamella edge prosenchymatous with hyphae 1-5 µm wide. **Lamellar trama** with rare oleiferous hyphae 4-6 µm wide and rare smooth vascular hyphae 3-5 µm wide. **Pileus subcutis** 30-70 µm thick, of tightly horizontal-interwoven, gelatinous, in mass pale ochre, filamentous hyphae 1-4 µm wide; also with granular oleiferous hyphae 4-8 µm wide, weakly SV+. **Pileus epicutis** 30-60 µm thick, embedded in a gelatinous matrix which extends 10 to 30 µm above the hyphal tips, a turf of inclined to erect, sparsely septate, unbranched, hyaline hyphae 1-2(-3) µm wide, apices rounded to acute; also numerous pileocystidia 30-120 x 4-8 µm, subcylindric to clavate, infrequently septate, filled, often sparsely, with refractive granules or short bands, weakly SV+, originating as apical cells of connective hyphae; also ascendant ends of oleiferous hyphae originating in the subcutis, tips cylindrical to clavate, rounded, 6-12 µm wide, weakly SV+. **Stipe**

cuticle of interwoven, septate, branched, hyaline hyphae 1-10 µm wide and common caulocystidia similar to the pileocystidia, consisting of both terminal cells of connective hyphae and ascendant ends of oleiferous hyphae; also with infrequent smooth vascular hyphae 4-8 µm wide.

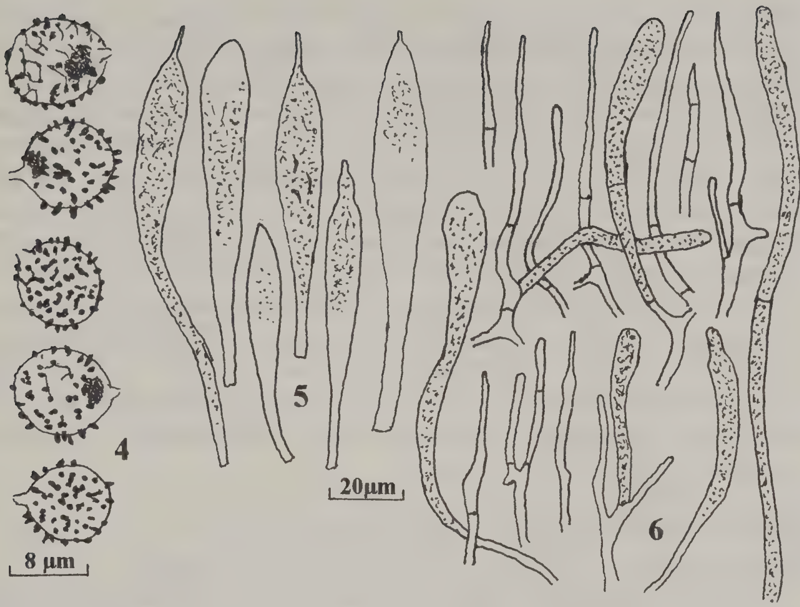
MATERIAL EXAMINED: NEW JERSEY: Morris Co.: Stephens State Park, 14 Sep 2001, Fatto 1303A; 17 Jul 2002, Fatto 1321. VIRGINIA: Giles Co., Singer V270 (FH).

OBSERVATIONS: The macroscopic description provided is of Fatto 1303A and 1321 which generally agrees well with Singer's. His desciption noted that the stipe was usually longer, 50-100 mm, than the pileus diameter, 45-75 mm. My specimens have a stipe length about equal to the pileus diameter. Features significant for microscopic confirmation would include the spores, averaging 8.6 x 6.9 µm with prominent warts to 1.2 µm in height and normally catenulate to some degree. Hymenial cystidia are numerous, fairly large, and prominently filled with banded and granular content. The most diagnostic feature is the pileus epicutis, with a turf of long, thin, 1-2 µm wide, hyaline, filamentous, unbranched, unagglutinated or separated hyphae embedded in a gelatinous matrix. The pileocystidia on the Singer specimen, unlike the hymenial cystidia, contain a spaced granular to short banded content which is now only weakly respondent to SV, however a fresh specimen has content that is uniformly granular and reactive to SV.

Russula maculata Quélet and Roze in Quélet, Bull. Soc. Bot. France 24: 323. 1878 ("1877"). Figs. 4-6

(Macroscopic description as a consensus of European literature:) **Pileus** to 10 cm, reddish orange, often with ochre areas and rusty red spots, cuticle shiny, separable only marginally. **Lamellae** maturing ochre-yellow, often forked. **Stipe** firm, white, browning, occasionally with pink areas near base. Odor of cedarwood. Taste slightly to moderately acrid. Spore color G-H (Romagnesi IVc-d). Habitat in deciduous (beech) forests.

Spores (7.6-)8-10.4(-11.2) x (6.4-)7-9.2(-9.6) µm, average size 9.2 x 8 µm, Q=1.15, subglobose to broadly obovate or broadly elliptic; ornamentation of amyloid warts 0.5-1(-1.2) µm high, cylindric to conic, isolated, connate, catenulate, often a few thin connectives but not forming a reticulum; suprahilar area an irregular lightly amyloid patch often marginally warted; hilar appendix inamyloid, inconspicuous. **Basidia** 42-58 x 10-14 µm, clavate, 4-sterigmate. **Hymenial cystidia** 60-112 x 8-14 µm, subcylindric, fusoid-clavate, apices predominantly acute, very few rounded, many mucronate or with aculeate appendage to 10 µm long, empty to centrally filled with granular content, (predominantly empty in Melzer's), mostly SV- but some granular areas a light refractive gray, arising from subhymenium or outer edge of trama, projecting to 15 µm but many embedded with only appendage projecting, common, margin homomorphous. **Subhymenium** 50-70 µm thick, pseudoparenchymatous, cells 6-10 µm wide at mid-lamella, becoming prosenchymatous at lamella edge, hyphae 1-4 µm wide. **Lamellar**



FIGS. 4-6. *Russula maculata* (Hoehnel 1348). 4. Spores. 5. Hymenial cystidia. 6. Hyphal ends from pileus cuticle.

trama with smooth vascular and oleiferous hyphae. **Pileus subcutis** 75-180 µm thick, of horizontal-interwoven, pale ochre in mass, filamentous hyphae 1.6-4 µm wide; also with common oleiferous and smooth vascular hyphae 2-6 µm wide. **Pileus epicutis** 75-160 µm thick, embedded in a gelatinous matrix extending 22-50 µm above hyphal tips and soon dissipating in KOH, a tangled trichoderm of ascending to erect, branching, septate, hyaline hyphae 1-4 µm wide, apices rounded to acute; pileocystidia common to numerous, 23-140 x 3-10 µm, clavate, subcylindric, non or rarely one septate, septum very fine (best observed when stained), content granular, weakly SV+, originating as cells of connective hyphae; also with ascendant ends of subcutal oleiferous hyphae, apices often strangulated, 6-10 µm wide, weakly graying in SV. **Stipe cuticle** of longitudinal-interwoven, non-gelatinous, septate, branched, hyaline hyphae 2-6 µm wide; also with common oleiferous hyphae 3-9 µm wide, refractive granular content weakly SV+, tightly packed at the appressed or projecting apical terminations and loosely dispersed elsewhere.

MATERIAL EXAMINED: AUSTRIA: Altenmarkt an der Triesting, 30 July 1905, Von Hoehnel 1348 (FH, sheet 3255). GERMANY: Gees, on slope under Fagus, Sept. 1987, Buyck 2552 (PC). UNITED KINGDOM: Surrey England: Wimbledon Common, 27 Aug 1904, Hartley-Smith (NY).

OBSERVATIONS: A description of fresh material is not recorded since none of my collections had similar microscopic characteristics and I have not seen a fresh collection.

This species is included in this paper to make readily available the information required to verify a tentative identification since this name has questionably been applied to American collections and is sometimes seen on foray lists. Inspection of some herbarium material of American collections with this name did not have microscopic characteristics as detailed above. I have not seen specimens of the taxon reported with this name from western North America. Salient microscopic features of the pileus cuticle include the thick gelatinous layer over the trichoderm of tangled, prominently septate hyphae with segments of irregular thickness, lower segments occasionally to 5 µm in width. The pileocystidia originating from the epicutal hyphae seem non-septate but treatment with Congo Red reveals an occasional, unusually fine septum. Also the ascendant ends of the subcutal oleiferous hyphae are often strangulated and subcapitate. Both the pileocystidia and hymenial cystidia contain a dispersed fine granular material with only a rare band rather than the strongly refractive bands observed in the hymenial cystidia of *R. macropoda*. Spores are more subglobose and noticeably larger in size, averaging 9.2 x 8 µm as compared to 8.6 x 6.9 µm for *R. macropoda*.

Russula tenuiceps Kauffman, Rep. Mich. Acad. Sci. 11: 81. 1909. Figs. 7-9
Syntype & Lectotype: C.H.Kauffman 534, 4 Sep 1906; bc.12262 (MICH)

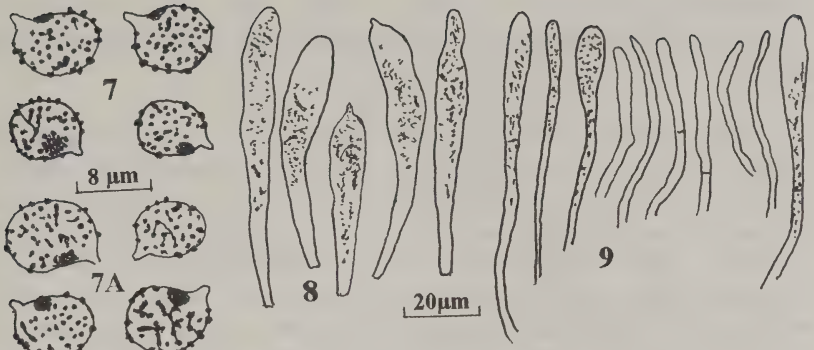
Kauffman's original published description: "Pileus 7-12 cm, broad, thin, fragile, convex to expanded, the somewhat viscid pellicle easily separable, margin at first connivent striate, deep rosy-red or blood-red, sometimes white spotted or tinged with orange blotches, sometimes uniform red with or without minute rugae. Flesh white, red beneath the cuticle, very fragile at maturty. Gills white, then yellow-ochraceous, crowded, narrow, fragile, narrowly adnate to free, few forked, interspaces venose, equal. Stem fragile, white or rosy-tinged, spongy-stuffed, subequal or ventricose, obscurely rivulose, white within and unchanged, 5-9 cm long, 2-2.5 cm thick. Spores yellow-ochraceous, subglobose, 6-8 micr., echinulate. Taste acrid, sometimes tardily but very acrid. Odor not marked.

Gregarious. Mixed woods at Marquette, in oak and maple woods at Ann Arbor. July and August. Rather frequent.

As in *R. veternosa*, it is probable that several forms are represented here. The red Russulas are very troublesome, and we seem to have a considerable number of forms with acrid taste and yellowish to deep ochraceous gills which can not be easily kept separate.... All the collections which I have referred here showed red on some or all of the stems of each collection."

The syntype collection consists of two specimens maintained in separate containers. One is a half pileus, 5 cm in diameter, without complete stipe, in good condition. The other is mature, with a complete pileus about 9.5 cm in diameter with a 9x2 cm stipe as dried. Most of the trama had apparently originally been consumed by maggots. The following microscopic observations are of the half pileus portion of the type.

Spores 6.4-8 x 5.2-6.4 µm, average size 7.3 x 5.8 µm, Q=1.26, broadly obovate to broadly elliptic; ornamentation of narrow amyloid warts 0.4-0.6(-0.8) µm high, isolated,



FIGS. 7-9. *Russula tenuiceps* (Kauffman 534, syntype & lectotype, half cap, bc.12262 MICH). 7. Spores. 7A. Spores (full cap). 8. Hymenial cystidia. 9. Hyphal ends from pileus cuticle.

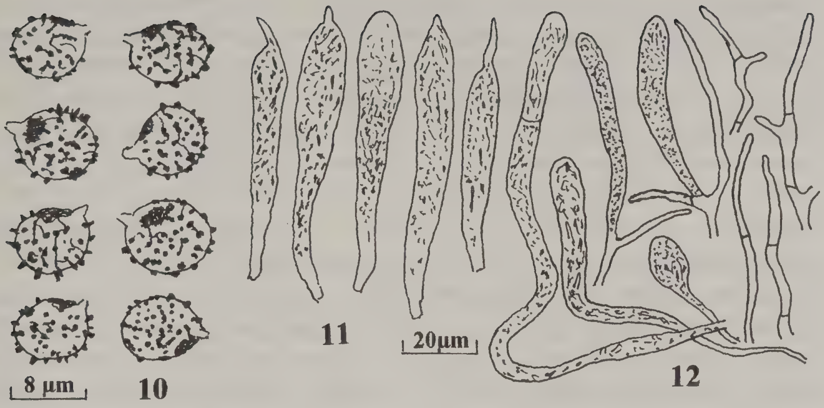
occasionally short catenulate, infrequently with a fine line connecting to 6 warts; suprahilar area a small amyloid patch; hilar appendix inamyloid, fairly prominent. **Basidia** 36-46 x 10-14 µm, clavate. **Hymenial cystidia** 44-74(-80) x 8-11 µm, clavate, fusoid-clavate, subcylindric, apices rounded, subacute, some mucronate or with a short thin appendage, content empty or with spaced granules and short bands in central to upper areas, SV-, arising from subhymenium or outer edge of trama, embedded or projecting to 16 µm, common. **Subhymenium** 30-35 µm thick, pseudoparenchymatous at mid-lamella, cells small, 3-6 µm wide, subgelatinous, marginal area prosenchymatous with subgelatinous hyphae 1-4 µm wide. **Lamellar trama** thin, with small sphaerocysts, interwoven connective hyphae, pseudoparenchyma and infrequent smooth vascular hyphae 2-10 µm wide. **Pileus subcutis** 76-120 µm thick, of horizontal-interwoven, filamentous hyphae 1-4 µm wide; also with infrequent oleiferous hyphae 2-4 µm wide, SV-, and smooth vascular hyphae. **Pileus epicutis** 46-75 µm thick, embedded in a thin gelatinous matrix which extends to 10 µm above the hyphal tips and quickly dissipates in KOH, a trichoderm of ascending to erect, septate, hyaline hyphae 1.6-3.6 µm wide, apices rounded; also with spaced pileocystidia, 4-6(-8) µm wide, subclavate to cylindric, septate, with dispersed granular content, SV-. **Stipe cuticle** of longitudinal-interwoven, branched, septate, hyaline hyphae 2-6 µm wide; also with relatively short, embedded to projecting caulocystidia 4-8 µm wide, cylindric to subclavate, empty or with light granular content, SV-, widely dispersed to moderately numerous in patches; also dispersed embedded oleiferous hyphae, the refractive granular content weakly graying in SV, and rare embedded, smooth vascular hyphae to 6 µm wide.

The second portion of the syntype was subsequently studied. Characteristics conformed with the above description but a slight difference in the spores was noted. Spores as reported on the half pileus specimen were present but a greater concentration of the larger spores with the higher warts and more connectives were observed. Spores from the larger pileus specimen were 6.4-8.8 x 5.2-6.8 µm, average size 7.6 x 6.1 µm, Q = 1.25, ornamentation of warts, narrow to obtuse, 0.3-0.8 µm high, isolated, short catenulate, short bands, or fine to thick connectives infrequently forming a closure or rarely a broken reticulum.

OBSERVATIONS: Examination of collections labeled *R. tenuiceps* in herbaria reveal that many species of *Russula* conform to Kauffman's macroscopic description and confirm his statement that "it is probable that several forms are represented here." For example, NY has a Kauffman collection from Ann Arbor, MI dated 7-25-1912 with spores and a pileus cuticle which are entirely different from this syntype; also a Burlingham collection from Newfane Hill, VT, under white birch, dated 9-12-1936, which also has different spores and pileus cuticle. Singer (1939) initially published a microscopic description of two specimens filed by Kauffman. He (1957) then redescribed this species, providing macroscopic details from his own collections, as a taxon without odor or weakly of pears, with a spore color varying from E to G, growing under hemlock. He placed it in subsection *Rubrinae* of *Russula* but later (1986) listed it in subsection *Urentinae*. An examination of the collections he cited indicated that at least four different species were included in his "material studied" section. Three of his Massachusetts collections in the Harvard herbarium (FH) appear to be of the same taxon which, according to his unpublished notes maintained at the Field Museum of Natural History (F), he called *R. purgetorii* ad int., ined. These have abundant pileo- and caulo- cystidia which darken strongly with SV, and a reported spore color of E. The Linder collection from New Hampshire is microscopically *R. luteispora* Murrill. For collection N1038 he recorded a spore color of G. This specimen differed from all other collections examined, exhibiting a trama coloration of deep reddish brown in SV and deep tannish yellow in KOH, besides other microscopic inconsistencies. Collection N884 is very similar to *R. subtenuiceps*. Collection N993 contains several specimens at MICH and F, some of which have characteristics closely approaching those of the *R. tenuiceps* syntype and may be young specimens. Several other collections were examined. None have microscopic characteristics equivalent to the syntype though the spores of all the taxa are rather similar.

Russula subtenuiceps Fatto, sp. nov. Figs. 10-12.

Pileus 4-8 cm latus, convexus maturans ad plano-depressum, margo aequus, aetate leviter tuberculatus-striatulus; cutis separabilis usque ad 3/4 partes radii, sordida siccata, constanter rufa-colorata valde et graviter; trama firma-fragilis, alba, immutans; sapor lente valde-acer; odor similis cedro. Lamellae adnatae, confertae, aequae, ochraceae pallidae-mediae. Stipes 3-7 x 1-2 cm, subtiliter pruinosus, longitrorsum rugulosus, cremicolor, typice lineatus usque ad roseus fere omnino, immutans. Sporae ochraceae accumulatae, (Romagnesi IVa-IVc), 6.8-8.8 x 5.6-7.2 µm, flocculae 0.4-0.8(-1) µm altae, separatae, breves-catenulatae cum paucis et gracilibus connectivis. Cystidia hymenialia 52-90 x 7-13 µm, subcylindrica, fusoideo-clavata, clavata, apices rotundati ad subacutos, mucronati, longi appendiculati, quod intus continetur vittatum aut granulatum. Pileus



FIGS. 10-12. *Russula subtenuiceps* (Fatto 620, holotype). 10. Spores. 11. Hymenial cystidia. 12. Hyphal ends from pileus cuticle.

cuticula 120-220 µm densa; subcutis habens hyphas horizontales-intertextas et filamentosas; epicutis ixotrichodermis cum hyphis tenuibus filamentosis et abundantibus pileocystidiis.

Holotypus: USA: Pennsylvania: Pike Co.: Pocono Environmental Education Center, sub *Tsuga canadensis*, 22 June 1991, R. M. Fatto 602, positus in herbario New York Botanical Gardens (NY).

Pileus 4-8 cm broad, pulvinate young, then convex and becoming plano-depressed, eventually with a wide central deeply depressed area, margin initially even, becoming weakly tuberculate-striate to 1 cm in age; cuticle viscid and shiny when moist, normally smooth but occasionally with tuberculate areas, soon drying and then dull, separable from 1/3 to 3/4 of the radius, uniformly colored a deep red near 16 dark Red, 13 deep Red, or M&P 6L9, 6L6, 7H6, occasionally lighter and including orange and ochre tones, near 38 dark reddish Orange or M&P 4G11, 5G12, 5K11; trama thin, 2-3 mm thick at mid-radius, firm-brittle, pink under the cuticle, otherwise white, unchanging; odor slight to strong, of cedarwood; taste very acrid, sometimes tardily. **Lamellae** 3-4 mm broad at mid-radius, subacute to even in front, adnate to adnexed, close to subcrowded, mostly equal but an occasional fork and long lamellulae are usually present, brittle, edges even, cream young but soon medium ochre. **Stipe** 3-7 cm long, 10-20 mm wide at midpoint, equal or tapered slightly upwards, base often attenuated, surface dry, minutely pruinose, longitudinally rugulose, cream but usually streaked or almost completely pink, in the areas of 5 moderate Pink to 2 strong Pink, M&P 2F3, 2F4, trama stuffed, white, unchanging.

Chemical reactions (stipe cuticle): SV purplish gray; 10% $FeSO_4$ tan; 2% Phenol purplish brown; formalin none; guaiac greenish-blue.

Spores ochraceous in mass, F to G, (M&P 9F3 to 10G3), or IVa to IVc, 6.8-8.8 x 5.6-7.2 µm, average size 7.7 x 6.4 µm, Q=1.21, broadly obovate to broadly elliptic;

ornamentation of amyloid warts 0.4-1 µm high, isolated, short catenulate, frequently with fine lines connecting 4-7 warts, rarely forming a closure; suprahilar area a fairly dark, slightly raised amyloid patch; hilar appendix inamyloid, inconspicuous. **Basidia** 30-44 x 10-12 µm, clavate, 4-sterigmate. **Hymenial cystidia** 46-82 x 7-12(-13) µm, subcylindric, fusoid-clavate, clavate, apices subacute to rounded, many either capitellate, mucronate, or appendiculate with the appendage rostrate or aculeate and extending to 12 µm, content granular to short banded, SV+, arising from subhymenium or outer edge of trama, embedded or projecting to 18 µm, numerous. **Subhymenium** 24-44 µm thick, pseudoparenchymatous, cells 4-10 µm wide at mid-lamella, becoming prosenchymatous with hyphae 2-4 µm wide at the lamella edge. **Lamellar trama** with rare oleiferous hyphae. **Pileus subcutis** 80-160 µm thick, salmon-pink, of interwoven, filamentous hyphae 2-5 µm wide; also with common SV+ oleiferous hyphae and rare smooth vascular hyphae 3-10 µm wide. **Pileus epicutis** 40-60 µm thick, embedded in a gelatinous matrix, thickness varying from not above hyphal tips to overlaying by 24 µm, a trichoderm of ascending to erect, septate, hyaline hyphae 1.6-2.4 µm wide, apices rounded, and abundant, SV+ pileocystidia, 22-110 x 2-8 µm as infrequently septate, clavate to subcylindric apical cells of connective hyphae and 4-10 µm wide, septate, ascendant tips of the subcutal oleiferous hyphae. **Stipe cuticle** of longitudinal-interwoven, nongelatinous, branched, septate, hyaline hyphae 2-6 µm wide; also abundant, cylindrical, repent or projecting to 60 µm, SV+, caulocystidia 5-8 µm wide and rare embedded smooth vascular hyphae 4 µm wide.

Habitat solitary to gregarious on ground under spruce or hemlock and mixed hemlock deciduous woods.

MATERIAL EXAMINED: CONNECTICUT: New London Co.: Salmon River State Forest, 14 Sep 1991, Fatto 644. MAINE: Hancock Co.: S. Brooksville, 20 Jul 1987, Fatto 215; 22 Jul 1987, Fatto 225; 29 Jul 1992, Fatto 665. Penobscot Co.: Old Town, 18 Jul 1988, Fatto 264. Orono, 11 Aug 1991, Fatto 627. NEW HAMPSHIRE: Cheshire Co.: Rindge, 18 Aug 1989, Fatto 436. NEW JERSEY: Sussex Co.: Stokes State Forest, 25 Sep 1988, Fatto 355. Warren Co.: Worthington State Forest, 19 Sep 1982, NJMA 1082. PENNSYLVANIA: Pike Co.: Pocono Environmental Education Center, 29 Jun 1985, Fatto 81; 23 Jun 1989, Fatto 378; 22 Jun 1991, Fatto 602 (Holotype, NY); 22 Jun 1996, Fatto 924; 27 Jun 1998, Fatto 1126; 24 Jun 2000, Fatto 1224.

OBSERVATIONS: With the exception of the distinctive cedarwood odor, *R. subtenuiceps* essentially falls within Singer's (1957) composite redescription of *R. tenuiceps*. However, it does differ from the syntype of *R. tenuiceps*. The spores of *R. subtenuiceps* are only slightly different, 7.7 x 6.4 µm vs. 7.6 x 6.1 µm, but with many warts 0.8-1 µm high vs. predominantly 0.4-0.6 µm for *R. tenuiceps*. The hymenial cystidia are conspicuous with abundant refractive granular banded content and many long apical appendages which were not observed on the lightly filled cystidia of *R. tenuiceps*. A tangential section of the pileus cuticle observed in SV revealed a strong pink to red cuticle containing unusually abundant, overlapping, black pileocystidia, whereas the cuticle of *R.*

tenuiceps was almost colorless to faintly pinkish-gray with spaced pileocystidia only slightly grayer than they appear in KOH. Likewise, the caulocystidia are abundant and SV+ while on *R. tenuiceps* they are dispersed and only faintly grayed in SV. The most diagnostic characteristic may be the unusual quantity of strongly SV+ pileocystidia in the epicutis. A color photograph published in Bessette (1997, p. 309) as *R. tenuiceps* is actually of *R. subtenuiceps*.

Russula fastigiata Fatto, sp. nov. Figs. 13-16

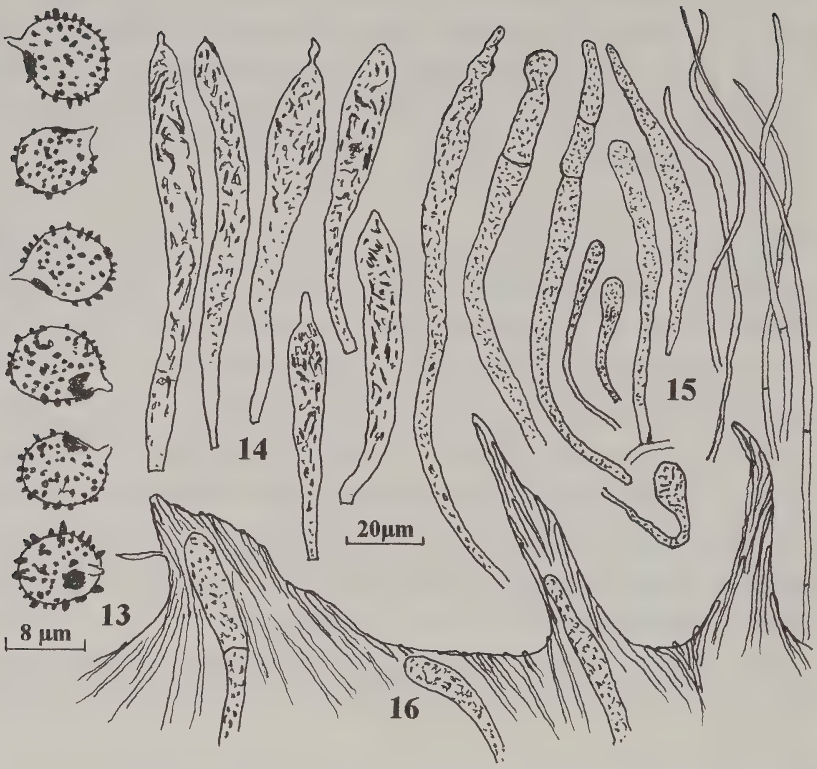
Pileus 6-11 cm latus, convexus cum margine incurva, maturans ad plano-depressum, margo aequus; cutis adnata, sordida siccata, obscure pruinosa, constanter et valde rufa-colorata; trama firma, alba, immutans; sapor lente intense-acer; odor perlevis, similis cedro. Lamellae adnatae, densae-confertae, aequae, ochraceae. Stipes 4-7 x 1.5-2.5 cm, glabrus, longitrorsum rugulosus, albus, immutans. Sporae ochraceae accumulatae, (Romagnesi IVc), 8-9.6 x 6.4-8 µm, flocculae 0.6-1(-1.2) µm altae, separatae ad breves-catenulatas. Cystidia hymenialia 60-106 x 8-14 µm, subcylindrica, fusoideo-clavata, apices rotundati ad acutos, mucronati, breves appendiculati, quod intus continetur vittatum aut granulatum. Pileus cuticula 120-200 µm densa; subcutis habens hyphas horizontales-intertextas et filamentosas; epicutis ixotrichodermis cum hyphis tenuibus et filamentosis atque abundantibus pileocystidiis agglutinatis quae certis temporibus fasciculos conicos formant.

Holotypus: USA: New Jersey: Morris Co.: Mendham town park, sub arboribus habens lignum durum, 10 July 1994, R. M. Fatto 794, positus in herbario New York Botanical Gardens (NY).

Pileus 6-11 cm broad, convex with incurved margin, aging plano-depressed, margin even; cuticle viscid when moist, soon dry, dull, faintly pruinose, adnate or separable to 1/4 of the radius, uniformly colored a strong red with tones near 13 deep Red, 16 dark Red, or M&P 6L6, 6L9, or sometimes a lighter red near 15 moderate Red, M&P 3G11, 4K11, and fading to an ochre-orange near 53 moderate Orange, M&P 12K11 or 11H8, disc may be slightly paler in age; trama 3-4 mm thick at mid-radius, firm, white, unchanging, odor slight, nondescript or faintly of cedarwood, taste slowly intensely acrid. **Lamellae** 3-6 mm broad at mid-radius, subacute in front, adnate, close to almost crowded, equal or with a rare fork or long lamellulae, brittle, edges even, pale ochre aging deep ochre, unchanging when injured. **Stipe** 4-7 cm long, 15-25 mm wide at midpoint, equal to slightly flared at apex, dry, dull, glabrous, longitudinally rugulose, firm becoming stuffed, white, unchanging when injured.

Chemical reactions (stipe surface): SV purplish brown; 10% $FeSO_4$ brownish salmon; 2% Phenol medium brown; formalin none; guaiac strong greenish-blue.

Spores ochraceous in mass, G or IVc, 8.0-9.6(-10.4) x 6.4-8.0 µm, average size 9.1 x 7.5 µm, Q=1.22, broadly elliptic to broadly obovate; ornamentation of amyloid warts 0.6-1(-1.2) µm high, to 0.8 µm wide, cylindric to conic, isolated, connate, some short



FIGS. 13-16. *Russula fastigiata* (Fatto 794, holotype). 13. Spores. 14. Hymenial cystidia. 15. Hyphal ends from pileus cuticle. 16. Agglutinated fascicles on pileus cuticle.

catenulate, or with a few fine connectives, without closures; suprahilar area a strongly amyloid patch; hilar appendix inconspicuous. **Basidia** 40-62 x 9-14 µm, narrowly clavate, usually 4-sterigmate, a few 2-sterigmate. **Hymenial cystidia** 60-106(-118) x 8-14 µm, subcylindric, fusoid-clavate, apices rounded, acute, most mucronate, capitellate, or short appendiculate, content short banded, granular, SV+, arising from subhymenium or outer edge of trama, projecting to 35 µm, numerous, margin homomorphous. **Subhymenium** 40-70 µm thick, pseudoparenchymatous, cells small, 4-8 µm wide at mid-lamella, at the lamella edge becoming prosenchymatous with hyphae 2-4 µm wide. **Lamellar trama** with smooth vascular hyphae 2-8 µm wide and rare oleiferous hyphae 2-4 µm wide. **Pileus subcutis** 56-110 µm thick, of horizontal-interwoven, nongelatinous, hyaline, filamentous hyphae 1.5-4 µm wide; also with common horizontal to ascending oleiferous hyphae 4-10 µm wide. **Pileus epicutis** 60-90(-120) µm thick, embedded in a gelatinous matrix not extending beyond hyphae, a trichoderm of erect to inclined hyaline hyphae 1-2.4 µm wide, 60-80 µm in length above the first septum, apices rounded to acute, agglutinated and periodically forming conical fascicles which extend 30-80(-120) µm beyond the normal surface; also with numerous pileocystidia 30-130 x 4-8 µm, clavate to subcylindric, aseptate or rarely with one or two septa, content granular, SV+, originating in the epicutis as apical cells of connective hyphae; also ascendant ends of subcutal oleiferous hyphae 4-10 µm wide, occasionally prominently septate, with clavate, strangulated capitate, or subacuminate apices. **Stipe cuticle** of longitudinal-interwoven, nongelatinous, occasionally branched, septate, hyaline hyphae 1-4 µm wide; also common to abundant, appressed to projecting ends of oleiferous hyphae, cylindric to clavate, 6-12 µm wide, content granular to banded, SV+, and rare embedded smooth vascular hyphae 4-8 µm wide.

Habitat solitary on soil in mixed hardwood, predominantly oak, forests.

MATERIAL EXAMINED: CONNECTICUT: New London Co.: Day Pond State Park, 25 Sep 1999, Fatto 1196. NEW JERSEY: Morris Co.: Mendham town park, 30 Jul 1989, Fatto 423; 12 Aug 1990, Fatto 548; 10 Jul 1994, Fatto 794 (Holotype, NY); Stephens State Park, 14 Aug 1988, Fatto 310; 14 Sep 2001, Fatto 1303; The Tourne, 16 Aug 1981, Fatto 5.

OBSERVATIONS: In the field the pileus of a small specimen could appear quite similar to *R. macropoda* in regard to color, lamellae, peeling, taste. Overall stature could distinguish between them since every collection of *R. fastigiata* had a pileus diameter which noticeably exceeded the stipe length, usually 8-9 cm with a stipe length of 5 cm. As noted for *R. macropoda* the stipe length exceeds or merely equals the pileus diameter. Microscopically the spores are larger, averaging 9.1 x 7.5 µm with warts more isolated as compared to 8.6 x 6.9 µm for *R. macropoda.* Although both species have long, unusually slender, unbranched, filamentous hyphae in the pileus cuticle, the cuticle on *R. fastigiata* is rather unique. The hyphae are agglutinated so that the individual hypha is barely discernible and they form slender conical to wide pyramidal fascicles which extend on average about 60 µm above the normal surface. A gelatinous matrix does not extend beyond the hyphal surface. Abundant SV+ short clavate pileocystidia are embedded in the agglutinated mass, as well as arising oleiferous hyphal ends which are often subacuminate or strangulated.

Russula luteofolia Fatto, sp. nov. Figs. 17-19

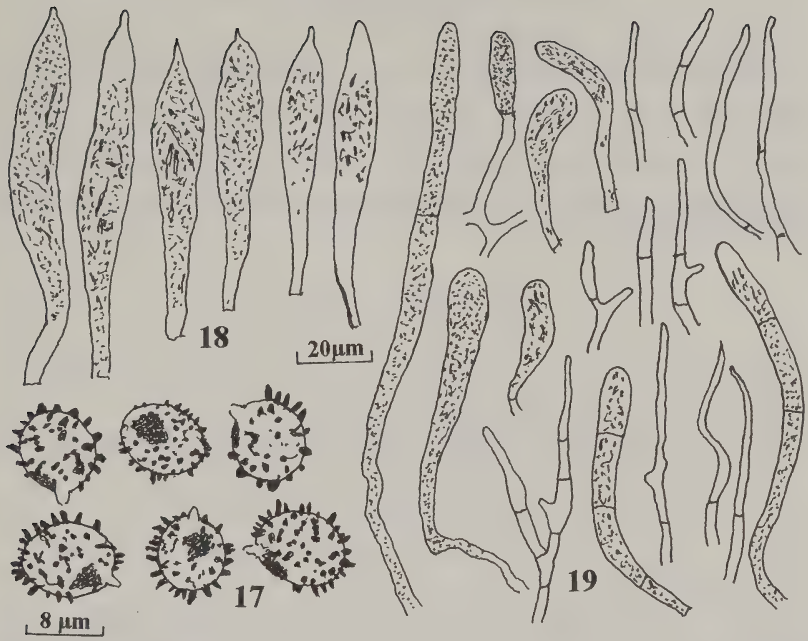
Pileus 4-8 cm latus, convexus, maturans planus cum disco alte-depresso et cum margine leviter sulcato; cutis separabilis usque ad 1/2 partem radii, glabra, media pallide-rubra, evanescens comprehendere ochreo-aurantios colores; trama tenuis, alba, immutans; sapor valde-acer; odor obscure-acutus, sine descriptione. Lamellae adnatae, densae, aequae, splendidae ochreo-luteae. Stipes 3-8 x 0.7-2 cm, glabrus, longitrorsum rugulosus, albus, immutans. Sporae valde luteo-ochraceae accumulatae, (Romagnesi IVe), 7.6-8.8(-9.2) x 6.4-7.2(-7.6) µm, flocculae 0.6-1.4 µm altae, plures seiunctae, breves-catenulatae. Cystidia hymenialia 56-98 x 8-14 µm, fusoidia, fusoideo-clavata, apices acuti, mucronati, breves-appendiculati, quod intus continetur granulatum ad breve vittatum. Pileus cuticula 130-230 µm densa; subcutis densa, cum hyphis intertextis et gelatinosis; epicutis tenuis, ixotrichodermis cum intertextis et ramosis hyphis septatis et tenuibus atque pileocystidiis abundantibus.

Holotypus: USA: New Jersey: Morris Co.: Stephens State Park, sub arboribus habens lignum durum, 10 September 2000, R. M. Fatto 1251, positus in herbario New York Botanical Gardens (NY).

Pileus 4-8 cm broad, convex with a slightly incurved margin young, in age plane with a deeply depressed disc, margin even or very slightly sulcate in age; cuticle viscid when moist, soon dry, dull, glabrous, separable 1/4-1/2 of the radius, a medium reddish color, in age tending to fade and include ochre-orange tones, near 15 moderate Red, M&P 4K10, 4L9, 5L10, fading in areas towards 37 moderate reddish Orange or 38 dark reddish Orange, M&P 3I11, to 4D10 or 5J11; trama thin, 2-4 mm at mid-radius, firm, white, unchanging; odor present, somewhat sharp, nondescript or faintly reminiscent of honey or gingerbread; taste strongly acrid. **Lamellae** 4-6 mm broad at mid-radius, subacute in front, becoming rounded in age, adnate to adnexed, thin, close, equal, a few long lamellulae, edges even, brittle, yellow young, M&P 9H4, maturing deeper yellow, M&P 11L7, unchanging when injured. **Stipe** 4-8 cm long, 7-20 mm wide at midpoint, equal to enlarging downward, dry, glabrous, longitudinally rugulose, firm becoming stuffed, white, unchanging when injured.

Chemical reactions (stipe surface): SV purplish brown; 10% $FeSO_4$ weak brownish salmon; 2% Phenol slowly to dark reddish brown; formalin none; guaiac deep greenish-blue.

Spores deep yellow ochre in mass, H+ or IVe+, 7.6-8.8(-9.2) x 6.4-7.2(-7.6) µm, average size 8.3 x 6.9 µm, Q=1.20, subglobose, broadly obovate to broadly elliptic; ornamentation of amyloid warts 0.6-1.4 µm high, to 0.8 µm wide, cylindric to conic, predominantly isolated to connate, few short catenulate or a rare line connecting 2-4 warts, no closures; suprahilar area a strongly amyloid irregular, marginally warted patch; hilar appendix inamyloid, inconspicuous. **Basidia** 36-52 x 10-14 µm clavate, 4-sterigmate. **Hymenial cystidia** 56-98 x 8-14 µm, fusoid, fusoid-clavate, apices acute, mucronate, short appendiculate, few rounded, content granular, short banded, SV+, arising from subhymenium to outer edge of trama, projecting 12-20 µm, numerous. **Subhymenium** 32-50 µm thick, pseudoparenchymatous, cells small 4-10 µm wide at mid-lamella, at the edge becoming prosenchymatous, hyphae 2-3 µm wide. **Lamellar trama** with rare oleiferous and smooth vascular hyphae 2-4 µm wide. **Pileus subcutis** 80-150 µm thick, of gelatinous, interwoven, hyaline hyphae 2-6 µm wide; also with oleiferous hyphae and rare smooth vascular hyphae. **Pileus epicutis** 50-80 µm thick, embedded in a gelatinous matrix not above or in areas extending to 10 µm above the hyphal tips, hyphae interwoven, ascending to erect, branched, septate, hyaline, 2-4 µm wide, apical cells acuminate to cylindric with rounded apices, usually 13-36 µm long beyond the first septa and 3.2-1.6 µm wide; also with abundant pileocystidia 20-130 x 4-10 µm, broadly clavate to subcylindric, aseptate to 2 septate, content finely granular,



FIGS. 17-19. *Russula luteofolia* (Fatto 1251, holotype). 17. Spores. 18. Hymenial cystidia. 19. Hyphal ends from pileus cuticle.

SV+, originating as apical cells of connective hyphae, and with ascendant ends of subcutal oleiferous hyphae 4-8 µm wide. **Stipe cuticle** of longitudinal-interwoven, nongelatinous, occasionally branched, septate, hyaline hyphae, 2-4 µm wide; also numerous appressed to projecting caulocystidia and ends of oleiferous hyphae, 3-8 µm wide, cylindrical with rounded apices, SV+, and rare embedded smooth vascular hyphae to 10 µm wide.

Habitat solitary on soil in mixed hardwood, predominantly oak, beech forests.

MATERIAL EXAMINED: MASSACHUSETTS: Berkshire Co.: North Adams, 16 Aug 1986, Fatto 183. Hampshire Co.: Amherst, 18 Aug 2001, Fatto 1282. NEW JERSEY: Morris Co.: Stephens State Park, 1 Sep 1985, Fatto 126; 31 Jul 1994, Fatto 815; 10 Sep 2000, Fatto 1251 (Holotype, NY); 14 Sep 2001, Fatto 1302. (Other than holotype, all in RMF personal herbarium).

OBSERVATIONS: Compared with the white-stiped *R. macropoda* and *R. fastigiata*, *R. luteofolia* has the smallest spores, averaging 8.3 x 6.9 µm with the longest, predominantly isolated, warts extending to 1.4 µm. However, color of the massed spores is the most diagnostic feature being as deep of a yellow-ochre as I have observed for a *Russula* species. In my copy of Romagnesi (1967) the illustrated color IVe equates to M&P 10K6. The massed spores of *R. luteofolia* are M&P 11K6 to 11L6. The smaller stature and equality of stipe length to pileus diameter also distinguish it from *R. fastigiata*.

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NAMES RELATED TO CORDYCEPS SINENSIS ANAMORPH

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ABSTRACT

Cordyceps sinensis is well known as a Chinese medicinal 'herb', used for its invigorating and immunological effects on the human body. Many efforts have been devoted to isolate and cultivate the fungus from nature in China since the 1980's. Twenty-two names, involving 13 genera, associated with the anamorph of *Cordyceps sinensis* are listed in the present paper and their nomenclatural status discussed. Two of the eight names formally proposed as new species are invalid according to the provisions of ICBN articles. Some other names were often mentioned as new species in Chinese literature, but they have not been formally described. The links between these names and the fungus *Cordyceps sinensis* are also discussed.

Key words: fungal names, nomenclature, anamorph, *Hirsutella sinensis*, *Paecilomyces sinensis*

INTRODUCTION

The Chinese 'Caterpillar Fungus', popularly referred to as 'Dong Chong Xia Cao' in Chinese or 'Hia Tsao Tong Tchong' and 'Hea Tsaon Tsong Chung' in early English translation (Pegler, Yao & Li 1994), has been widely used in traditional Chinese herbal medicine. It is well known for its invigorating effects in strengthening the body and restoring energy (e.g. Pegler et al. 1994). Recent work has shown that it has multiple pharmaceutical effects on human body, e.g.

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sedation, bronchial dilatation (Lei et al. 1992), anti-ageing, stimulating and strengthening the immune faculty (Guo & Yang 1999) and serving as an effective cure for renal injury (Tian et al. 1991, Guo & Yang 1999), etc.

The fungus involved in the 'Caterpillar Fungus' was first scientifically described under the name *Sphaeria sinensis* Berk. (1843) in the western world, although it has been known much earlier in Chinese literature (Wang 1995). Saccardo (1878) placed the species within *Cordyceps* (Fr.) Link (1833), as *C. sinensis* (Berk.) Sacc., and this has been accepted ever since. The fungus parasitizes the larvae of moths (*Lepidoptera*), especially *Hepialus armoricanus* Obertheir which is the most well documented host species.

The fungus is endemic on the Tibetan Plateau and may be found only from above 3000 m altitude up to the snow-line (Xiao et al. 1983, Li & Cao 1990, Wang 1995), usually between 3600 - 5000 m according to the authors' personal collecting experience. The natural production of the fungus is limited and the annual yield has been declining continually over recent years (Yang 1997). However, the use of the fungal products in medicinal treatment and in health foods has become very popular in China, and the fungus is exported to many countries for this purpose. The fall in supply and increasing demand have stimulated interests in the search for substitutes of the natural products of the fungus, and have also prompted the CITES Management Authority of China to list the species as 'endangered species for protection' in 2000 (CITES Management Authority of China & China Customers 2000). Since the 1980's, much effort has been devoted to isolating the fungus from nature and to its cultivation in vitro. Many strains have been isolated from the ascospores and the stroma of the fungus, and from the sclerotium formed by the fungus within the exoskeleton of the moth larva. It has proved very difficult to get the fungus to produce the teleomorph in laboratory, although several claims are made and patents have been lodged for successful cultivation of the fungus to produce similar stromata, ascocarps and ascospores to those found in nature (Shen et al. 1983, 1985, Yin & Shen 1990). However, only the mycelium, conidiophores and conidia are usually produced. As a result, various names have been applied to the *C. sinensis* anamorph, either strains isolated from material of the fungus or postulated asexual states of the fungus.

Several attempts have been made to summarize the names related to the *C. sinensis* anamorph and various numbers are proposed. For example, 10 names were included by Liu (1990), 14 strains by Liang P. -Q. (1991), 9 names by Lin and Yu (1997), 13 names in the key to anamorphs isolated from *C. sinensis* by Wang et al. (1998), 8 names by Li et al. (2000), 7 names by Liu et al. (2001) and 11 species in 10 genera by Liang Z. -Q. (2001). The precise number of names that have been applied to the possible anamorph of *C. sinensis*, however, remains unclear and the relationships between anamorphic names and the teleomorph are still uncertain. To clarify this situation, a systematic survey of the literature was completed over the last two years and the results are reported in the present paper.

NAMES RELATED TO THE *CORDYCEPS SINENSIS* ANAMORPH

Some 22 names, in 13 genera, associated with the anamorph of *C. sinensis* have been found from this literature investigation. They are listed in Table 1 with references and notes on their nomenclatural status. All these names have been referred to isolates from material of *C. sinensis* in the reference cited, except for '*Scydalium* sp.' sensu Liang & Lu (1990) and *Verticillium* sp. sensu Liu (1990) which are not explicitly indicated in the report.

DISCUSSION

Among the listed names, some are widely used in referring to the products from *Cordyceps sinensis* in research papers and in government documents (Ministry of Health, People's Republic of China 2001), together with a few names that have not even been validly published, e.g. *Paecilomyces hepiali* and *Hirsutella hepiali*. The nomenclature for the anamorph of *Cordyceps sinensis* is in need of clarification, as the names bear information on the important resources of *C. sinensis* and are critical to material commercially used for human consumption.

Eight names have been proposed as new species with descriptions of the anamorphic fungus involved. Among them, six have fulfilled the requirements for valid publication according to the ICBN. Two names, *Paecilomyces hepiali* and *Synnematium sinense*, failed to comply with the provisions of these articles. Of the validly published names, five are listed in the Index of Fungi, except *Mortierella hepiali*, which was published in a university journal within China.

There are four names mentioned as 'sp. nov.' in various articles but lack valid publication, i.e. *Cephalosporium dongchongxiacae*, *C. sinensis*, *Hirsutella hepiali* and *Verticillium sinensis*, although the latter was originally listed as published elsewhere. There is another name, '*P. lingi*', which appeared only in an article without the author for the name or other elements essential for publication of a fungal name.

Cephalosporium acremoneum Corda is a zygomycetous species of *Umbelopsis* Amos & H. L. Barnett (Gams 1971, pers. comm.), although the name has been applied apparently to a fungus with septate hyphae isolated from *Cordycpes sinensis*, whilst *Cephalosporium acremoneum* sensu auct . plur. non Corda has been renamed as *Acremonium strictum* W. Gams (Gams 1971). *Isaria farinosa* has been combined as *Paecilomyces farinosus* (Holmsk.) A. H. S. Br. & G. Sm. (Brown & Smith 1957).

Table 1. Anamorphic names related to *Cordyceps sinensis*

No.	Name	First publication	References	Notes
1	*Cephalosporium acremonium* Corda	*Icones Fungorum* 3: 11 (1839)	Song et al. (1988)	Correct name: *Acremonium strictum* W. Gams
2	*Cephalosporium dongchongxiacae* N. Y. Shen, S. M. Zhang, L. Lu, X. C. Zhang & S. L. Wei	*China Patent* No. 85101971 (1985)	Shen et al. (1985), Liang & Lu (1990)	*nom. inval.*, = *Hirsutella sinensis*
3	*Cephalosporium sinensis* C. T. Chen	*Chinese Traditional and Herbal Drugs* 18(7): 45 (1987)	Jing et al. (1987)	*nom. nud.*, =? *Hirsutella sinensis*
4	*Cephalosporium* sp. sensu Liu (1990)		Liu (1990)	= *Hirsutella sinensis*
5	*Chrysosporium sinense* Z. Q. Liang	*Acta Mycologica Sinica* 10: 51 (1991)	Liang Z. -Q. (1991)	*sp. nov.*, Index of Fungi 6: 134
6	*Hirsutella hepiali* C. T. Chen & N. Y. Shen	*Edible Fungi* 1995(6): 6 (1995)	Zhang & He (1995)	*nom. nud.*, = *Hirsutella sinensis*
7	*Hirsutella sinensis* X. J. Liu, Y. L. Guo, Y. X. Yu & W. Zeng	*Acta Mycologica Sinica* 8: 37 (1989)	Liu et al. (1989)	*sp. nov.*, Index of Fungi 5: 964
8	*Isaria farinosa* (Holmsk.) Fr.	*Systema Mycologicum* 3: 271 (1832)	Cheng & Bai (1995)	= *Paecilomyces farinosus* (Holmsk.) A. H. S. Br. & G Sm.
9	*Isaria* sp. sensu Zhang et al. (1992)		Zhang et al. (1992), Chu (1997a, b)	
10	*Metarhizium anisopliae*	*Rastitel'nye parazity cheloveka i*	Guo et al. (1998)	

	(Metschn.) Sorokin	*zhivotnykh kak prichina zarazhykh bolezne* (Petersburg) 2: 268 (1883).		
11	*Mortierella hepiali* C. T. Chen & B. Liu	*Journal of Shanxi University* 1986(4): 70 (1986)	Chen et al. (1986)	*sp. nov.*, not recorded in Index of Fungi.
12	*Paecilomyces hepiali* C. T. Chen & R. Q. Dai	*Acta Agriculturae Universitatis Pekinensis* 15: 223 (1989). *nom. inval.*	Dai et al. (1989)	*nom. inval.*
13	*Paecilomyces lingi* Anon.	*Research & Application of Chinese Entomogenous Fungi* 2: 67 (1991)	Fang (1991)	*nom. tant.*
14	*Paecilomyces sinensis* C. T. Chen, S. R. Xiao & Z. Y. Shi	*Acta Mycologica Sinica* 3: 25 (1984)	Chen et al. (1984)	*sp. nov.*, Index of Fungi 5: 356
15	*Scydalium* sp. sensu Liang & Lu (1990)		Liang & Lu (1990)	Correct spelling: *Scytalidium* sp.
16	*Scytalidium hepiali* C. Lan Li	*Acta Mycologica Sinica* 7: 24 (1988).	Li & Sun (1988)	*sp. nov.*, Index of Fungi 5: 781
17	*Sporothrix insectorum* de Hoog & H.C. Evans	*Studies in Mycology*. 7: 25 (1974)	Li et al. (2000)	
18	*Stachybotrys* sp. sensu Kobayasi (1982)		Kobayasi（1982）	
19	*Synnematium sinense* X. C. Yin & N. Y. Shen	*Acta Biologica Plateau Sinica* 9: 1 (1990).	Yin & Shen (1990)	*nom. inval.*, = *Hirsutella sinensis*
20	*Tolypocladium sinense* C. Lan Li	*Acta Mycologica Sinica* 7: 93 (1988).	Li (1988)	*sp. nov.*, Index of Fungi 5: 846
21	*Verticillium sinensis* Wei Wang	*Acta Edulis Fungi* 5(4): 18 (1998)	Wang et al. (1998)	*nom. ined.*
22	*Verticillium* sp. sensu Liu (1990)		Liu (1990)	

The relationships between different anamorphic names are complicated by this inconsistent use of names. Five names, such as *Cephalosporium dongchongxiacae*, *C.* sp. sensu Liu (1990), *Hirsutella hepiali*, *H. sinensis* and *S. sinense* are synonyms, judged from the publications investigated. *Cephalosporium sinensis* may also have been referred to the same anamorphic species, but this remains uncertian owing to the lack of published information. Among these names, *H. sinensis* is the only validly published name and the rest should be discarded. Some of the anamorphic strains were identified only to generic level, e.g. *Isaria* sp., *Scytalidium* (as *Scydalium*) sp., *Stachybotrys* sp. and *Verticillium* sp., and there was no further information available for positive identification. Thus, their relationships with other anamorphic names in the same genera remain unclear.

Hirsutella sinensis has been considered the correct anamorph of *Cordyceps sinensis* and this has been supported by several independent groups using molecular methods, e.g. DNA sequence analyses by Zhao et al. (1999), Chen. et al. (2001), Liu et al. (2001) and RAPD experiments by Li et al. (2000). Two names are excluded from the possible anamorph of *C. sinensis* based on molecular evidence, i.e. *Paecilomyces sinensis* by Li et al. (2000), Zhao et al. (1999), Chen et al. (2001) and *Sporothrix insectorum* by Li et al. (2000). *Mortierella hepiali* belongs to *Zygomycota* and cannot be the anamorph of *C. sinensis*, a species of *Ascomycota*. It is said that *Chrysosporium sinense* is not the anamorph of *Cordyceps sinensis* because the similarity in RAPD polymorphism between them is very low (Li et al. 2000), but additional evidences not published. *Metarhizium anisopliae* is unlikely to be an anamorphic fungus of *Cordyceps sinensis* as its distribution is very wide and not restricted to high altitude, and, further, it has been found on a broad range of insect hosts (Pu & Li 1996). The links between other anamorphic names and *C. sinensis* remains dubious and further experimental evidences are required to clarify them.

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NEW SPECIES OF ANNULATASCUS AND SACCARDOELLA FROM THE PHILIPPINES

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ABSTRACT: *Annulatascus liputii* sp. nov. and *Saccardoella minuta* sp. nov. found on woody substrates submerged in the Liput River in the Philippines, are described, illustrated and compared with similar taxa. The confusion surrounding the genus *Saccardoella* is also discussed. A key to species of *Saccardoella* is provided.

KEYWORDS: ascomycetes, freshwater fungi, lignicolous fungi, taxonomy.

INTRODUCTION

The genus *Annulatascus* was established to accommodate *A. velatisporus* K.D. Hyde and *A. bipolaris* K.D. Hyde (Hyde 1992a). Twelve species are presently included in the genus (Tsui et al. 2002). *Annulatascus* species are characterized by black, immersed to superficial ascomata with long necks, cylindrical, unitunicate asci with relative large, refractive apical rings and fusiform, hyaline ascospores with sheaths (Hyde 1992a, Tsui et al. 2002).

Saccardoella was described to accommodate *S. montellica* Speg. (Spegazzini 1879) and has been reviewed by Petrak (1962) and Hyde (1992b). Characteristics include large, immersed to erumpent ascomata, long cylindrical asci with an apical ring and uniseriate ascospores having several transverse septa and sheaths or appendages (Petrak 1962, Hyde 1992b, Barr 1994).

In an ongoing study of freshwater mycota in Asia (e.g. Ho et al. 1999, Hyde et al. 1999, Goh & Hyde 1999), we identified two taxa of ascomycetes from woody substrates submerged in the Liput River in the Philippines. Critical examination showed that they are undescribed species of *Annulatascus* and *Saccardoella*, which are, therefore, described as new and compared with similar taxa in this paper. Tsui et al. (1998) provided a key to species of *Saccardoella*. The key is updated in this paper with the additions of *S. allequashensis* Fallah & Shearer, *S. graeweana* (Blomb.) M.E. Barr, L. Holm & K. Holm, *S. horizontalis* Fallah & Shearer, *S. lacustris* Fallah & Shearer, and *S. minuta* L. Cai & K.D. Hyde (Barr et al. 1998, Fallah & Shearer 2001). The confusion surrounding *Saccardoella* is discussed.

MATERIALS AND METHODS

Submerged bamboo culms were collected by V.A. Hyde from a small stream, the Liput River, near Bario Alegria, Negros Occidental at the Philippines Centre for Mycological Research. Samples were processed and examined following the methods described in Tsui et al. (2000). Single spore isolations were carried out as detailed by Choi et al. (1999) with the cultures deposited in HKUCC. Type material is deposited at PDD, with isotype and paratypes at HKU(M).

TAXONOMY

Annulatascus liputii L. Cai & K.D. Hyde, sp. nov.

Figs. 1-11

Ascomata 180-260 µm diam., 200-300 µm alta, globosa vel subglobosa, immersa vel superficialia, coriacea, atro-brunnea vel nigra, solitaria vel gregaria, ostiolata, papillata. Asci 130-187.5 × 8.5-10 µm, 8-spori, cylindrici, unitunicati, leptodermi, apparato apicale, J- praediti. Ascosporae 15-22.5 × 6.5-7.5 µm, uniseriatae, fusiformes, hyalinae, unicellularae, 2-septatae ad maturam, laevae, leptodermi, tunica gelatinosa praeditae.

Etymology: referring to the river where this fungus was collected.

Ascomata 180-260 µm diam., 200-300 µm high, globose to subglobose, immersed to superficial, coriaceous, dark brown to black, with axis horizontal or vertical to the host surface, with apical neck, solitary or gregarious, ostiolate, papillate (Fig. 1); necks 250-400 × 45-70 µm, cylindrical, periphysate. Peridium 15-30 µm wide, *textura angularis* in surface view, dark brown-walled compressed cells with 3-4 inner layers of hyaline and elongate cells (Figs. 2-4). Paraphyses 4-5 µm wide at the base, filamentous, numerous, unbranched, septate, hyaline, and tapering distally (Fig. 5). Asci 130-187.5 × 8.5-10 µm ($\bar{x}$ = 162.5 × 9.5 µm, n = 10), 8-spored, cylindrical, pedicellate, unitunicate, thin-walled, persistent, with a distinct refractive J- apical ring (*ca* 3.5 µm diam., 2 µm high) (Figs. 6-8). Ascospores 15-22.5 × 6.5-7.5 µm ($\bar{x}$ = 19 × 7 µm, n = 25), overlapping uniseriate, fusiform, hyaline, unicellular when young, becoming 2-septate at maturity, smooth and thin-walled, surrounded by a thin mucilaginous sheath (Figs. 9-11).

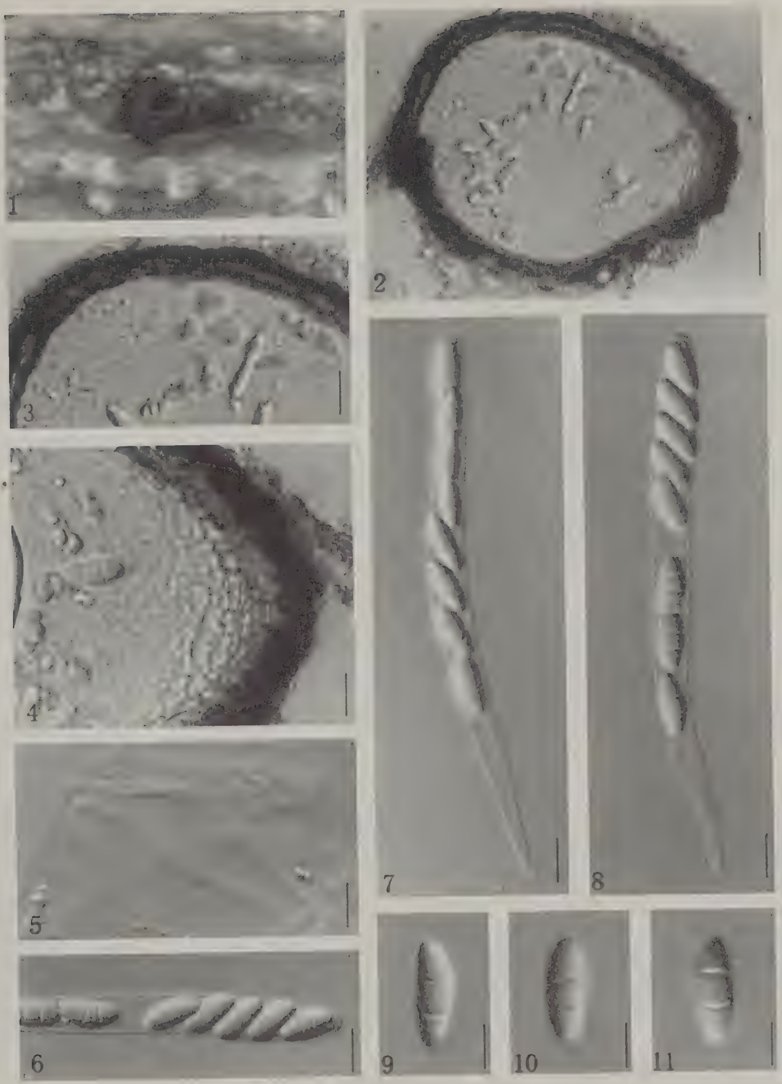
Colonies on potato dextrose agar slow growing, reaching 3 cm diam. after 1 month at room temperature (~ 22° C), cottony, with aerial mycelium, greyish-brown, with feathery edges; reverse dark brown. No fruiting bodies or anamorph formed in culture (HKUCC 2168, 2169).

Habitat: Saprobic on submerged bamboo.

Known distribution: Philippines.

Holotype: Philippines, Negros Occidental, Bario Alegria, Lupit River (a small stream), on submerged bamboo, 18 August 2001, V.A. Hyde (PDD 75038).

Paratypes: Philippines, Negros Occidental, Bario Alegria, Lupit River (a small stream), on submerged bamboo, 18 August 2001, V.A. Hyde (HKU(M)17101); *ibid.* (HKU(M)17103).



Figs. 1-11. *Annulatascus liputii*, from holotype. 1. Ascoma on the surface of substrate. 2-4. Section of ascoma. 5. Paraphyses. 6-8. Asci. Note the apical ring in 6. 9-11. Ascospores. Scale bars: 1 = 200 µm. 2-3, 5-8 = 20 µm. 4, 9-11 = 10 µm.

Other material examined: Philippines, Negros Occidental, Bario Alegria, Lupit River (a small stream), on submerged bamboo, 27 April 1997, K.D. Hyde (HKU(M) 5178); *ibid.* (HKU(M) 4780).

Notes: Our species is most similar to *Annulatascus aquaticus* W.H. Ho, K.D. Hyde & Hodgkiss (Ho et al. 1999) since it has similar sized ascospores (19-24 × 6-8 μm vs. 15-22.5 × 6.5-7.5 μm). The shape and septation of the ascospores are, however, different. In *A. aquaticus*, ascospores are unicellular with rather acute ends. In *A. liputii*, ascospores are (0)-2-septate and short fusiform. *Annulatascus aquaticus* also has a larger ascal apical ring than *A. liputii* (4.5-5 μm diam., 3.5-4 μm high in *A. aquaticus* vs. *ca.* 3.5 μm diam., 2 μm high in *A. liputii*). *Annulatascus liputii* is also comparable to *A. citriosporus* J. Fröhlich, & K.D. Hyde, *A. palmietensis* K.D. Hyde and *A. triseptatus* S.W. Wong, K.D. Hyde & E.B.G. Jones, but can be distinguished by the different number of septa in the ascospores (aseptate in *A. citriosporus*, 3-septate in *A. palmietensis* and *A. triseptatus* vs. (0)-2-septate in *A. liputii*).

Saccardoella minuta L. Cai and K.D. Hyde, sp. nov.

Figs. 12-22

Ascomata 420-700 μm diam., globosa or subglobosa, subclypeo immersa, coriacea, atro-brunnea vel nigra, solitaria vel gregaria, ostiolata, papillata. Papilla nigra, conica, ad per 200 μm alta, 250 μm in diam. Asci 112.5-137.5 × 3.5-4.5 μm, 8-spori, longe cylindrici, pedicellati, unitunicati, leptodermi, apparato apicale praediti. Ascosporae 12.5-22 × 3-4 μm, uniseriatae, fusiformes, hyalinae, 3-septatae, ad septa constrictae, vagina inconspicuae.

Etymology. Referring to the small ascospores.

Ascomata 420-700 μm diam., up to 750 μm high, globose to subglobose, immersed, coriaceous, dark brown to black, solitary or gregarious, ostiolate, papillate (Fig. 12). Clypeus extending outwards around the papilla, composed of small densely pigmented cells in the host tissue. Papilla black, up to 200 μm high, 250 μm diam. Peridium 20-30 μm wide, composed of two strata: an inner stratum of several layers composed of angular brown thin-walled cells forming a *textura angularis*, and an outer stratum composed of fungal hyphae interspersed with host cells forming a *textura intricata* (Fig. 13). Paraphyses numerous, 1 μm diam, filamentous and hypha-like (Fig. 18). Asci 112.5-137.5 × 3.5-4.5 μm ($\overline{x}$ = 125 × 3.5 μm, n = 10), 8-spored, long-cylindrical, short-pedicellate, unitunicate, thin-walled, apically rounded, with a faint ring-like apical apparatus (Figs. 14-17). Ascospores 12.5-22 × 3-4 μm ($\overline{x}$ = 16 × 3.5 μm, n = 25), overlapping uniseriate, fusiform, ends rounded, hyaline, 3-septate, slightly constricted at the septa, surrounded by an inconspicuous mucilaginous sheath (Figs. 19-22).

Colonies on potato dextrose agar up to 1.5 cm diam. in 7 days at room temperature (~ 22 °C), superficial, cottony, with abundant aerial mycelium, pale brown

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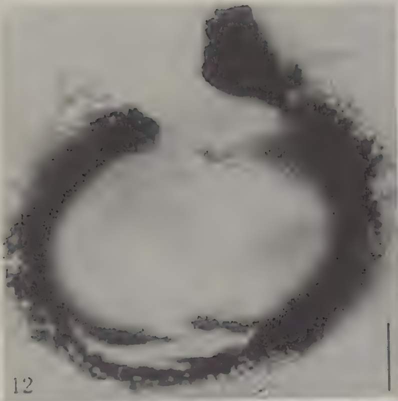
Figs. 12-22. *Saccardoella minuta,* from holotype. 12. Section of ascoma. 13. Peridium. 14-17. Asci with uniseriate ascospores. 18. Paraphyses. 19-22. Ascospores. Scale bars: 12 = 30 μm, 13 = 20 μm, 14-15, 18 = 10 μm, 16-17, 19-22 = 4 μm.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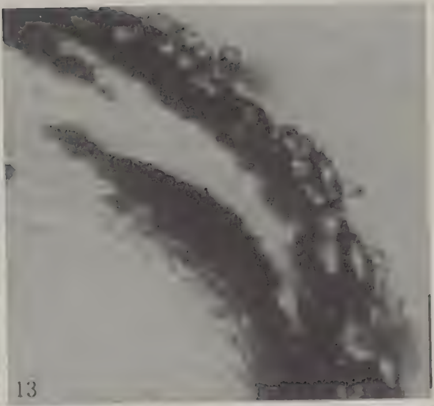
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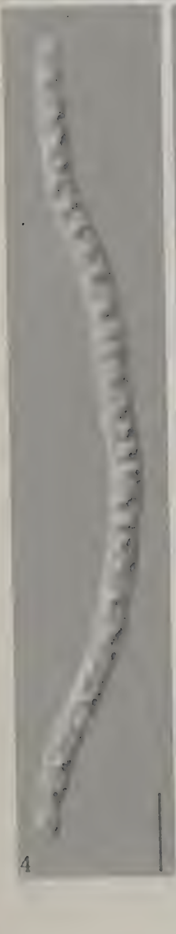
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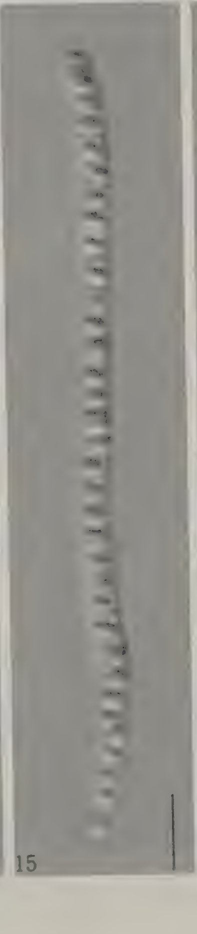
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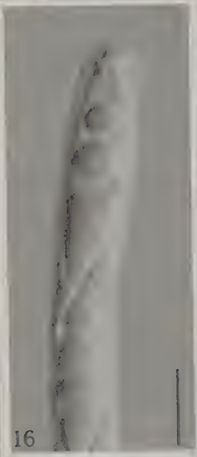
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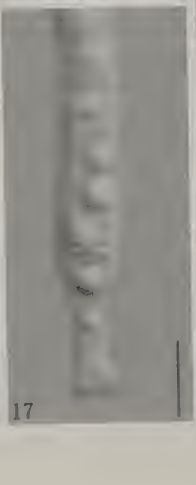
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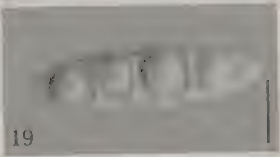
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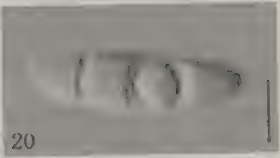
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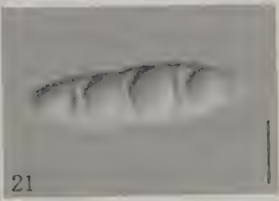
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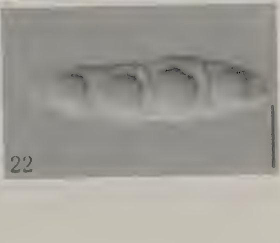
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in centre and white towards the margin from above; reverse pale brown in the centre, white towards the margin, margin regular. Hyphae 2-3.5 μm wide, hyaline, septate, branched and smooth-walled, no fruiting bodies or anamorph formed in culture (HKUCC 9078).

Habitat: Saprobic on submerged bamboo.
Known distribution: Philippines.
Holotype: Philippines, Negros Occidental, Bario Alegria, Liput River (a small stream), on submerged bamboo, 18 August 2001, V.A. Hyde (PDD 75037). Isotype: HKU(M) 17102.

Notes: *Saccardoella minuta* is distinct in having the smallest ascospores in this genus. It is most comparable with *S. macrasca* (Sacc.) M.E. Barr since it has 3-septate ascospores. *Saccardoella macrasca*, however, has consistently wider asci (100-150 × 6-9 μm vs. 112.5-137.5 × 3.5-4.5 μm) and larger ascospores (16-36 × 4-5.5 μm vs. 12.5-22 × 3-4 μm), and differs from *S. minuta* in having distoseptate ascospores which taper towards their apices (Barr 1994). *Saccardoella minuta* is also comparable with *S. aquatica* Tsui et al. (1998) as it has 3-septate ascospores which are similar in shape. *Saccardoella aquatica*, however, has much larger ascospores (26-34 × 6-7 μm vs. 12.5-22 × 3-4 μm) and asci (185-230 × 7-9 μm vs. 112.5-137.5 × 3.5-4.5 μm) than *S. minuta*.

Saccardoella species have been reported from various habitats such as freshwater (e.g. *S. allequashensis* Fallah & Shearer, *S. horizontalis* Fallah & Shearer, *S. lacustris* Fallah & Shearer, *S. minuta* L. Cai & K.D. Hyde, *S. aquatica* K.M. Tsui, K.D. Hyde, Hodgkiss & Goh), marine (e.g. *S. mangrovei* K.D. Hyde, *S. rhizophorae* K.D. Hyde, *S. marinospora* K.D. Hyde) and terrestrial (e.g. *S. miscanthi* W.H. Hsieh, C.Y. Chien & Sivan., *S. mascrasca* (Sacc.) M.E. Barr, *S. separans* M.E. Barr). The genus is heterogenous as it includes species that are clearly not related. Two of the three *Saccardoella* species from mangroves have distosepate ascospores, while asci in all mangrove species have a faint ring-like subapical apparatus and narrow paraphyses (2 μm) in a gelatinous matrix (Hyde 1992b). Two of the three north American species discussed by Barr (1994) and Barr et al. (1998) also have distoseptate ascospores; in all species asci are also illustrated with a subapical ring-like apparatus and paraphyses are relatively narrow. In the freshwater species described by Tsui et al. (1998), the ascospores are euseptate, asci have a similar subapical apparatus to the above species, while paraphyses are wider. The nature of the asci in these species is not clear, they may be unitunicate or less probably bitunicate, but they do appear to have a group of characteristic features.

Hsieh et al. (1997) described a species from *Miscanthus* from Taiwan. *Saccardoella miscanthi* W.H. Hsieh, C.Y. Chen & Sivan. has 10-16-septate fusiform ascospores with well-defined septa, asci have an indistinct long amyloid apical ring and relatively wide (2 μm) paraphyses. Three species have also been described from freshwater by Fallah and Shearer (2001), but it is unlikely that these should be retained in the genus. In *Saccardoella allequashensis* Fallah & Shearer ascospores are 5-euseptate, asci have a refractive apical ring and paraphyses are relatively wide, being more typical of *Aquaticola* (Ho et al. 1999). In *S. horizontalis* Fallah & Shearer ascospores have 7-(8) distinct eusepta, asci have a refractive apical ring and paraphyses are relatively wide; this species could be accommodated in *Rivulicola* (Hyde et al. 1997) or possibly *Vertexicola* (Ranghoo et al. 2000). In *S. lacustris* Fallah & Shearer ascospores are 5-7(-8) euseptate, asci are cylindric-clavate with a refractive apical ring and paraphyses are relatively wide. The ascomata and peridium of this species is also atypical of *Saccardoella*.

One of the main problems in *Saccardoella* is that the type species does not appear to have been re-examined since it was introduced by Spegazzini (1879). The concept of the genus is confusing. Nevertheless, we still include all the published species in an updated key in this paper with the exception of the excluded species, *S. berberidis* Eliasson, *S. canadensis* Ellis & Everh., and *S. dehliana* Malhotra & Mukerji. (Mathiassen 1993, Hsieh et al. 1997, Tsui et al. 1998).

Because of the heterogenous characters in this genus, the placement of *Saccardoella* at the family level is also confusing. Petrak (1962) placed the genus in Sphaeriaceae. Barr (1990) placed it in Clypeosphaeriaceae, as asci lacked fissitunicate dehiscence. However, asci in this genus appear to be thickened, and when asci break up under a slide, release of inner gelatinous material is reminiscent of fissitunicate dehiscence (Hyde 1992b). Barr (1994) reconsidered the placement of *Saccardoella* and placed it in the Pleurotremataceae as it has hyaline, symmetric, frequently distoseptate ascospores in short stipitate, cylindric asci whose apical ring is narrow, nonamyloid and whose pulvillus is indistinct. In the latest Dictionary of the Fungi, *Saccardoella* is placed in the *genera incertae sedis* (Kirk et al. 2001), Molecular studies are required in order to ascertain the familial position of the genus.

Key to species of *Saccardoella*

1. Ascospores lacking sheaths or appendages 2
1. Ascospores with a mucilaginous sheath or appendages.............................. 6
2. Ascospores 3-septate, 16-36 × 4-5.5 μm ....*S. macrasca*
2. Ascospores with more than 3 septa 3
3. Ascospores 11-18-septate, 35-60.5 × 7.3-10.5 μm, distinctly constricted at the central septum .... *S. kanderana*
3. Ascospores not constricted at the central septum.............................. 4
4. Ascospores 7-(8)-septate, 32-38 × 7-10 μm..............................*S. horizontalis*
4. Ascospores mostly with more than 7 septa 5
5. Ascospores 7-19-septate, 45-50 × 8-9 μm. .... *S. transsylvanica*
5. Ascospores 10-14-septate at maturity, 30-40 × 3-5-5 μm..............................*S. graeweana*
6. Ascospores with appendages.............................. 7
6. Ascospores with a mucilaginous sheath.............................. 10
7. Ascospores with cap-like appendages.............................. 8
7. Ascospores with long terminal polar appendages 9
8. Ascospores 45-50 × 4-8 μm, 5-7(-8)-septate..............................*S. lacustris*
8. Ascospores 65-85 × 8-9 μm, 18-23-septate..............................*S. separans*
9. Ascospores 70-100 × 9 μm, 35-38-septate..............................*S. ingridae*
9. Ascospores 100-115× 12 μm, 20-30-septate..............................*S. montellica*
10. Ascospores 3-septate.............................. 11
10. Ascospores with more than 3 septa 13

11. Ascospores 12.5-20 × 3.5-4 µm .... *S. minuta*
11. Ascospores longer than 25 µm, and wider than 5 µm 12
12. Ascospores 26-34 × 6-8 µm, fusiform, constricted at septa ....*S. aquatica*
12. Ascospores 25-31 × 7.5-10 µm, broadly ellipsoidal, not constricted at septa…… ....*S. marinospora*
13. Ascospores with more than 9 septa, 38-50 × 3.5-4.5 µm, with swollen cell in the middle ....*S. miscanthi*
13. Ascospores with less than 9-septa 14
14. Ascospores 26-33 × 6-8 µm, 7-9-septate .... *S. mangrovei*
14. Ascospores with less than 7 septa 15
15. Ascospores 19-26 × 6-8 µm, ellipsoidal, septa thickened ....*S. rhizophorae*
15. Ascospores 16-28 × 6-8 µm, broadly fusiform, not thickened at septa ....*S. allequashensis*

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DICTYOCEPHALOS ATTENUATUS (AGARICALES, PHELLORINIACEAE) NEW RECORD FROM ARGENTINA

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ABSTRACT

Dictyocephalos attenuatus, a rare species from xeric areas, is described macro- and microscopically for the first time from Argentina. It is compared with the close species *Phellorinia herculanea*.

Key Words: chorology, *Phellorinia herculanea*, South America, taxonomy.

INTRODUCTION

The province of Catamarca is located in the NW Argentina. Six phytogeographic provinces are distinguished in this territory, some of them being characterized by the presence of xerophitic vegetation, with species such as *Aspidosperma quebracho-blanco* Schltdl., *Acacia aroma* Gillies ex Hook. & Arn., *Larrea divaricata* Cav., *Larrea cuneifolia* Cav., *Geoffroea decorticans* (Gillies ex Hook. & Arn.) Burkart, *Prosopis sp.,* and abundant Cactaceae. The important wealth of some groups of Gasteromycetes, adapted to these areas of Catamarca, has been of interest to us since 1998. Some results from these studies have been published by DIOS *et al.* (2000, 2001).

Now we present the first record of a rare species for Argentina, *Dictyocephalos attenuatus* (Peck) Long & Plunkett, belonging to fam. Phelloriniaceae, currently included in Agaricales (KIRK *et al.*, 2001).

MATERIAL AND METHODS

The material studied has been kept in the herbarium of the Universidad de Alcalá, Spain (AH), and there is a duplicate (gleba) in Mª.M. Dios' private herbarium.

The SEM photographs have been obtained following the method described by MORENO *et al.* (1995).

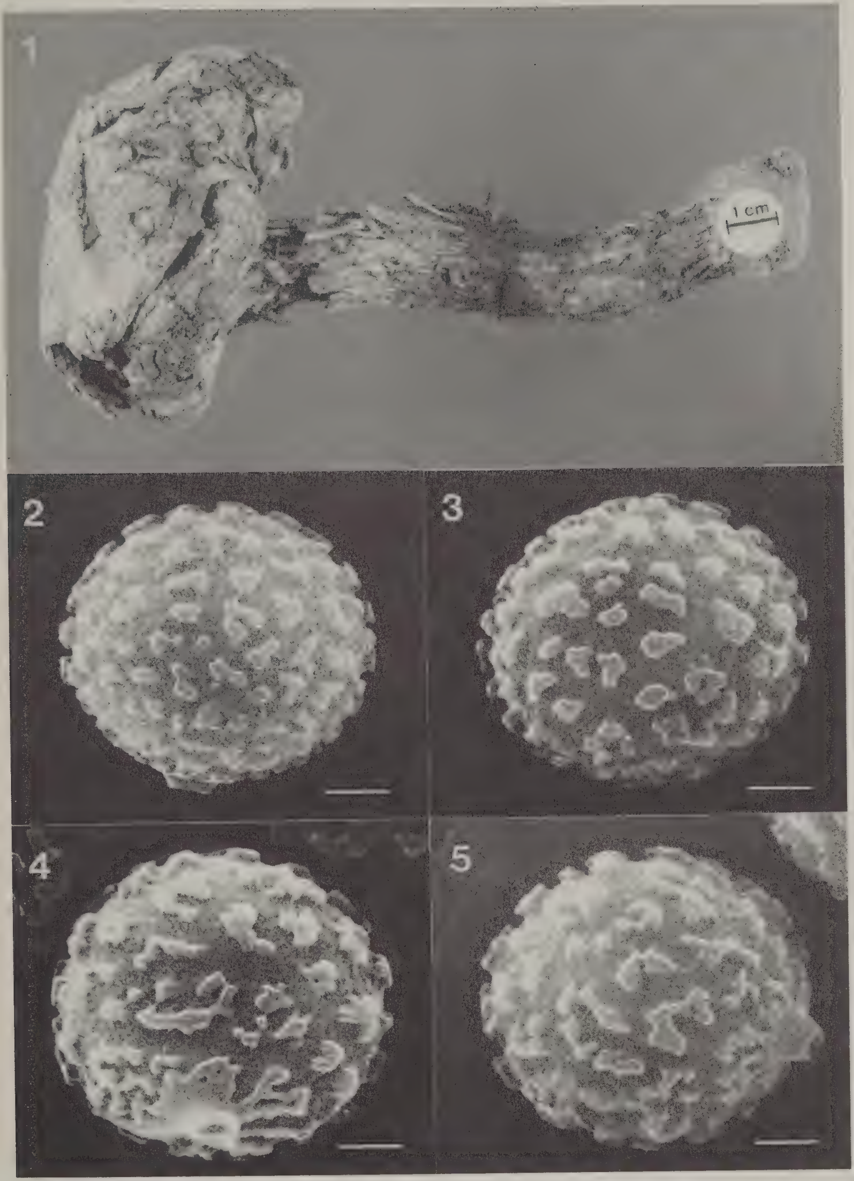
DESCRIPTION

Dictyocephalos attenuatus (Peck) Long & Plunkett, *Mycologia* 32(6): 697 (1940). (FIGS. 1-5)

≡ *Battarrea attenuata* Peck, *Bull. Torrey Bot. Club* 22: 208 (1895).
= *Dictyocephalos curvatus* Underw. *in* V.S. White, *Bull. Torrey Bot. Club* 28(8): 421-444 (1901).
= *Whetstonia strobiliformis* Lloyd, *Mycol. Notes Lloyd Libr. Mus.* 22: 270 (1906), fide LONG & PLUNKETT (1940).
= *Battarraeopsis artini* P. Henn., *Hedwigia* 41: 212 (1912), fide LONG & PLUNKETT (1940).
= *Phellorinia gigantea* Maire & Pat., *Bull. Soc. Hist. Nat. Afrique N.* 20(9): 279-281 (1929), fide MALENÇON (1951).

Material studied: ARGENTINA: Catamarca, Dept. Valle Viejo, area with cleared autochthonous vegetation (*Prosopis sp, Aspidosperma quebracho-blanco, Acacia aroma, Larrea sp. Geoffroea decorticans* and Cactaceae), *M.A. Sánchez-Giménez*, 12-I-2002, AH 28458, duplo (slides) in Mª.M. Dios' private herbarium nº 56.

The collection consists of only one basidiocarp (Fig. 1), not completely mature when it was collected, that reaches 150 mm length. The spore-sac measures 32 mm high and 70-80 mm wide, dorsiventraly flattened, that contains the most of the peridium and gleba. This peridium shows a whitish colour, externally ornamented with scales of variable thickness (1–2 mm), and whose dehiscence takes place by irregular and progressive breakage. The mentioned peridium scales are formed by branched hyphae of 2-4.5 µm diam, thin-walled, and with scarce septa. The stem is 120 mm long and 20 mm diam, woody, curved-sinuous, covered by long scales, and with a bulbous base of 25 mm diam, without remains of volva. The upper part of the stem hardly penetrates in the spore-sac, originating a slightly convex and not very widened structure. The gleba is composed of the ferrugineous brown spore mass and abundant groups or bunches of hyaline, subglobose and persistent basidia-basidioles (6,5–10 x 5–7 µm), which appear like small



FIGS. 1-5. *Dictyocephalos attenuatus* AH 28458. 1. Basidiocarp showing the remains of the peridium. 2-5. Variation of the spore ornamentation under SEM. Scale bar = 1 µm.

granules when observed under the stereomicroscope. The presence of frequent whitish remains can be also observed in the gleba. These remains come from the degradation of the membranous plates that typically divide in compartments the gleba in this species. This glebal "network" (LONG & PLUNKETT, 1940) also leaves more or less obvious, reticulate remnants in the internal surface of the peridium in this material. The globose to subglobose spores measure 5-6 µm diam, with verrucose ornamentation and ochraceous colour. Under SEM the spore ornamentation appears formed by irregular and not very developed verrucae (Figs. 2-5). In addition, some scarce hyaline, slightly sinuous, thin-walled, septate and cyanophilous hyphae (paracapillitium) can be observed in the gleba.

OBSERVATIONS

Phellorinia herculanea (Pallas: Pers.) Kreisel is a close species that presents the same microscopy (MARTÍN *et al*., 2000), with only some macroscopic distinctive features. Some authors (LONG & PLUNKETT, 1940; MORENO *et al*., 1997) have indicated that one of the main differences between both genera is the presence of thin membranous plates in the gleba of *Dictyocephalos*, and so the gleba remains divided in compartments. This kind of glebal framework has not been described for *Phellorinia* in the literature. Nevertheless, we have observed that thin whitish membranous plates appear in the gleba of an immature Spanish collection of *Phellorinia herculanea* (AH 28459). But certainly these membranes have not been observed in the completely mature basidiocarps, and nor leave the characteristic reticulate remains in the persistent base of mature spore-sacs either. Therefore, considering this observation, we can maintain that the presence of these membranes in the gleba, even though being shared by both genera of Phelloriniaceae, is a more remarkable and evident character in *Dictyocephalos*, specially in mature basidiocarps. The relative different size of the basidiocarps of these genera has been repeatedly pointed as a distinctive character, the basidiocarps of *Dictyocephalos* being larger and more robust than those of *Phellorinia.* But the great variation observed for this character leads us to consider it with caution. Then, the structure of the spore-sac remains as the main distinctive feature among these genera: pyriform shape in *Phellorinia*, and peridium continuous with the stem cortex, remaining as "a cupulate or urceolate expansion of stem apex" (LONG, 1946) when mature; the mentioned continuity between peridium and stem does not appear in more globose and robust basidiocarps of *Dictyocephalos*, remaining as a widened and blunt structure, more or less developed and prominent ("discoid apex" as said by LONG & PLUNKETT, 1940), that persists holding the remains of gleba after the disintegration of the spore-sac.

Often a depression (socket, collar) more or less evident around the insertion of the stem in the spore-sac can be observed, making more patent the mentioned difference.

With so scarce and variable macroscopic differences (no microscopic one) between both monospecific genera, the description of multiple synonymous species and the confusion in the determination of collections does not seem strange. Example of this is the case of the spectacular species *Phellorinia strobilina*, probably synonymous with *Dictyocephalos attenuatus* (LONG & PLUNKETT, 1940), that has been combined as *D. strobilinus* (Kalchbr.) Vassilkov (VASSILKOV, 1954). Another example is the Argentinian material presented here, which clearly belongs to the species *D. attenuatus* in our opinion, but shows a somewhat atypical structure: the stem apex is less widened and prominent than usual (a very variable feature according to LONG & PLUNKETT, 1940), and the remains of the membranous reticulum are not so evident. An additional question that complicates the differentiation of these species is that they share the adaptation to the same arid and semiarid environments, the presence of both in the same geographical area being possible. This fact has been observed in Los Monegros, Spain (MARTÍN & ROCABRUNA, 1988; MORENO *et al.* 1997). The collection studied in the present paper is the first published record of *D. attenuatus* from Argentina, being this species absent in the compilation articles by WRIGHT (1949) and DOMÍNGUEZ DE TOLEDO (1989). But it is also new record from all South America. Therefore, the area of distribution of *D. attenuatus* is notably wider, limited till now to some areas of North America, Africa (LONG & PLUNKETT, 1940; MALENÇON, 1935), Asia (VASSILKOV, 1954; SCHWARZMAN & FILIMONOVA, 1970), and South Europe (WRIGHT *et al.*, 1993; MORENO *et al.*, 1997; CALONGE, 1998).

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PSEUDOBAEOSPORA MUTABILIS, A NEW SPECIES DISCOVERED IN SLOVAKIA

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Abstract

Pseudobaeospora mutabilis a new species collected in Slovakia, is described. The typical characters of the species are the small almost round spores, the presence of broadly clavate to subglobose cheilocystidia, the erect position of the elements of the pileipellis composed of inflated, short cells, and the colour change of the pileipellis to bluish grey after bruising.

Key words: taxonomy, fungi, Agaricaceae, Agaricales.

Introduction

The genus *Pseudobaeospora* Singer is a little known member of the family *Agaricaceae*. Singer (1942) described the genus in a determination key and designated *Baeospora oligophylla* Singer (= *Pseudobaeospora oligophylla* (Singer) Singer) as the type. Among other differentiating characters, he indicated small, dextrinoid spores and a violet pigmentation as typical for the genus. Locquin (1952) enlarged the original concept of the genus (which had included until then only the type species) and included two species of the later genus *Sericeomyces* Heinem, which has longer, narrowly ellipsoid spores and white basidiocarps. Horak (1964), Moser (1983) and recently also Bas (1995) accepted the genus in its original narrower concept, including only violet taxa with small spores. However, both Singer (1975) and Moser (1986) maintained the concept of Locquin. The fruit-bodies recently collected in Slovakia obviously belong to a species of the genus *Pseudobaeospora* in its narrow sense.

The Slovakian fruit-bodies have broadly clavate to utriform cheilocystidia, clamp-connections in all parts, very small spores (3.0-3.7 × 2.7-3.5 μm), a pileipellis composed of erect chains of inflated cells and the surface of the pileus turning bluish grey when bruised.

Bas & Kriegelsteiner (1998) listed 5 species of the genus *Pseudobaeospora* known from Europe and in addition described the new species *P. pyrifera* Bas & L. Krieglsteiner. None of the known species of *Pseudobaeospora* has such a combination of characters as the species from Slovakia (see above). Therefore we are describing it as new.

Colour notations begining with ‘K&W’ refer to Kornerup A. & Wanscher J.H. (1978): Methuen handbook of colour, Third edition. Eyre Methuen Ltd., London.

Pseudobaeospora mutabilis Bas & Adamčík, *sp. nova.*

Pileus 7-13 mm latus, initio hemisphericus, demum subapplanatus, vulgo subumbonatus, centro obscure griseo-brunneus vel violaceo-griseo-brunneus, margine roseo-griseus vel griseo-roseus, demum ubi contusus griseo-caerulescens. Lamellae subconfertae (L = ± 18, l = 1-3), fere liberae, violaceae. Stipes 20-30 x 1-2 mm, concoloratus, pruinosus, basi albo-tomentosus.

Sporae 3.0-3.7 × 2.7-3.5 μm, Q = 1.05-1.15, medium Q = 1.1, globosae vel subglobosae, raro late ellipsoideae, initio tenuiter tunicatae et inamyloideae, demum crasse tunicatae et dextrinoideae, incoloratae. Basidia 4-sporigera. Cheilocystidia 10-24 × 7-11 μm, vulgo late clavata, infrequenter anguste clavata vel subglobosa, raro utriformia vel subcapitata. Pleurocystidia nulla. Pileipellis ope KOH 5% interdum pallide violacea, semper demum pallide viridis, hymenidermoidea; cellulae terminales ± erectae 15-30 × 7-14 μm, vulgo late clavatae vel (sub)globosae, infrequenter anguste clavatae, subcylindricae vel subutriformes. Fibulae praesentes.

***Holotypus hic designatus:** "S. Adamčík, V. Stanová & A. Viceníková, 12.VIII.1998, Slovakia, Záhorská nižina lowland, Abrod National Reserve (SAV)."*

Macromorphological characters: Pileus 7-13 mm in diameter, hemispherical to almost plane, usually with low umbo at centre, dark grey-brown to dark violaceous grey-brown (K&W 10F3 to 11E3), at margin greyish pink to pinkish grey (K&W 11B4 to 11C3), changing to bluish grey when bruised; surface finely granulose, smooth; margin not or weakly striated. Stipe 20-30 × 1-2 mm, with similar colours as pileus, finely pruinose, with white tomentum on base, hollow. Lamellae almost free, dense, violet, with concolorous, entire edge (L = ± 18, l = 1-3). Flesh without distinct smell, greyish pink; taste mild.

Micromorphological characters: Spores 3.0-3.7(-3.9) × 2.7-3.5(-3.7) μm, Q = (1.00-)1.05-1.15(-1.25), average Q = 1.10, colourless, at first thin-walled and inamyloid, later thick-walled and dextrinoid, colourless, smooth, with abrupt 0.4-0.7 μm long hilar appendage. Basidia 19-27 × 5-6.5 μm, 4-spored, with clamp-connection. Sclerified basidia scattered to rather abundant, with thick dextrinoid wall. Cheilocystidia 10-24(-30) × (5.5-)7-11(-18) μm, mostly broadly to very broadly clavate, less frequently slenderly clavate or subglobose, rarely utriform to subcapitate, or somewhat irregularly shaped, thin-walled and colourless. Pleurocystidia absent. Pileipellis almost an hymeniderm, consisting of erect chains of inflated cells; terminal cells (9-)15-30(-35) × (5-)7-14(-17) μm, predominantly broadly clavate to (sub)globose, more rarely narrowly clavate to subcylindrical or subutriform, smooth, thin-walled and colourless. A fragment of the pileipellis in KOH 5% turning at first pale violet or not, but soon becoming pale green. Caulocystidia at apex of stipe single or more frequently in tufts, 12.5-29(-37) x 4-11.5 μm, broadly to narrowly clavate, utriform, or somewhat irregularly shaped, rarely (sub)capitate. Clamp-connections present in all tissues.

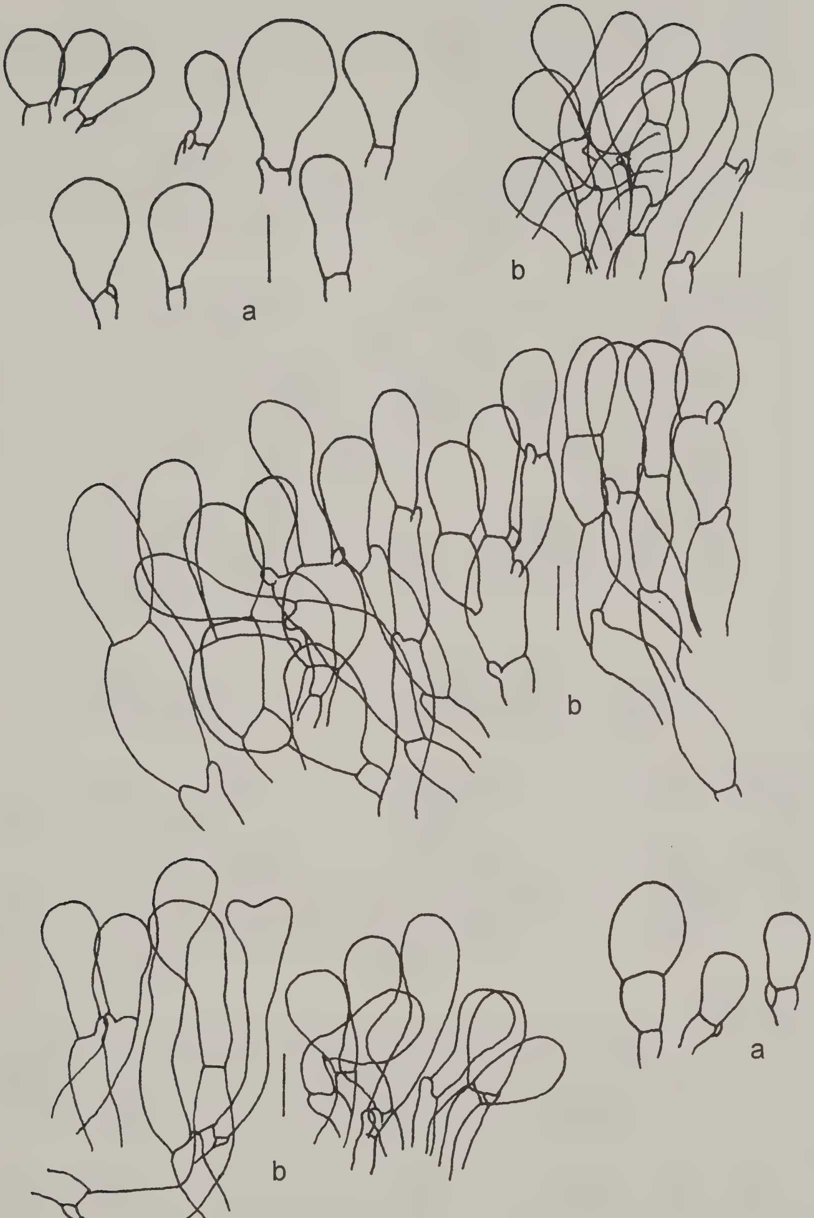

Fig. 1. *Pseudobaeospora mutabilis*. a - cheilocystidia, b - pileipellis. (Bar = 10 µm ; all figs from type)

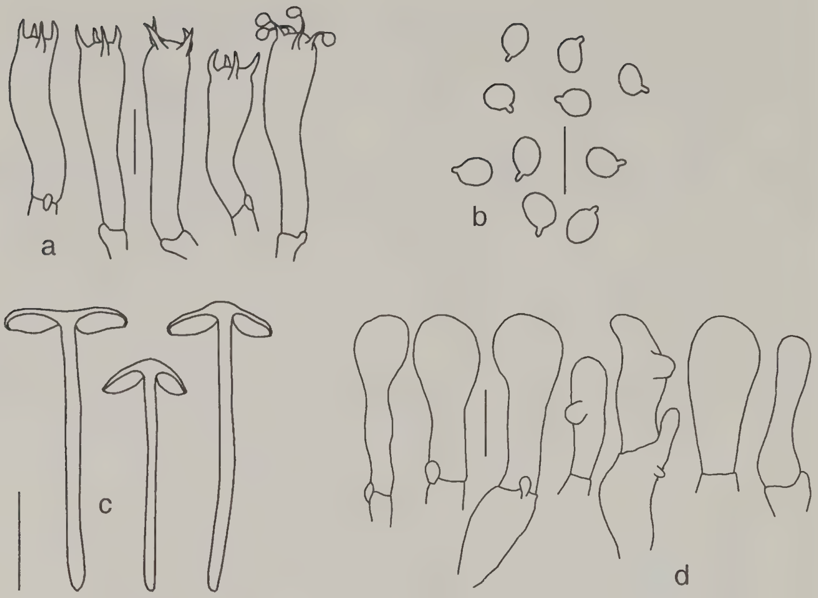

Fig. 2. *Pseudobaeospora mutabilis*. a – basidia , b - spores, c - basidiocarps, d - caulocystidia. (Fig. 1a, b and d bar = 10 μm, fig. 1c bar = 1 cm; all figs from type)

Collections examined: Slovakia, Záhorská nížina lowland, the Abrod National Reserve, among tall vegetation of *Mollinia caerulea*, near solitary *Betula* trees and *Frangula alnus* bushes, associated with *Clavulinopsis luteonana*, *Clavaria* sp., *Entoloma argenteostriatum*, *E. carneogriseum*, *E. conferendum*, *E. queletii*, *Hygrocybe aurantioviscida*, *H. conica*, *H. insipida*, *Ramariopsis crocea*, *R. kunzei*, on moist sandy soil, 3 collections: 12.VIII.1998, Adamčík and Stanová (SAV); 10.IX.1998, Adamčík, Stanová and Viceníková (SAV); 15.IX.1999, Adamčík, Antonín and Kabát (SAV).

Observations

The only other species of *Pseudobaeospora* with a pileipellis that is made up of erect elements is *P. celluloderma* Bas (2003). But that species does not have cheilocystidia. Moreover, it has very small basidiocarps (pileus 1-4.5 mm in diam. and stipe 11-35 x 0.1-0.8 mm) and somewhat larger and more ellipsoid spores, 3.5-4.4 x 2.6-3.5 μm, Q = 1.15-1.40, average Q = (1.20-)1.25-1.35.

The present species has many characters in common with *P. pyrifera* Bas & L. Krieglsteiner (Bas & Krieglsteiner 1998), but that species has a pileipellis that at the centre of the pileus consists of rather irregularly disposed short inflated cells forming a more or less pseudoparenchymatic tissue and outside the centre consists of repent chains of inflated cells. In addition its basidiocarps seem to be somewhat sturdier (pileus 5-23 mm in diam., stipe 11-35 x 2.6-3.5 mm) and the lamellae more crowded (L = 20- 24; l = 3).

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NEW LICHENS FOR TURKEY

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ABSTRACT

Five lichen species, *Lobothallia alphoplaca* (Hymeneliaceae), *Peccania coralloides* (Lichinaceae), *Pertusaria ocellata* (Pertusariaceae), *Toninia opuntioides* (Biatoraceae) and *Usnea chaetophora* (Parmeliaceae) are new records for Turkey.

Keywords : Crustose lichens, lichenized ascomycetes.

INTRODUCTION

About 1000 lichen species have been reported from Turkey, as the addition of species lists from recent publications shows. These include studies conducted in the provinces Eskişehir (Özdemir 1991), Oltu (Erzurum) (Aslan and Öztürk 1994), Erzurum, Artvin and Kars (Aslan 2000), Van (Akdamar İsland) (Aslan and Öztürk 1998), and Bursa (Güvenç and Aslan 1994), (Güvenç, Aslan and Öztürk 1995). Moreover new records published in recent years (Öztürk, 1990, Yazıcı, 1995, Gönülol et al. 1995, Öztürk and Kaynak 1999, Yazıcı and Aslan 2002a,b, Aslan et al. 2002). And some lists of lichen species compiled from previous research (John 1996 a,b, John and Nimis 1998). Unfortunately, many regions of Turkey are still not covered by lichenological works. This study provides five new records for the lichen flora of Turkey. All species were found in the East and Northeast Anatolia region.

MATERIAL AND METHODS

The lichen samples were collected from 5 different stations in Artvin, Giresun and Erzurum in June - October 1999. They were identified by using various floras (Purvis et al. 1992, Wirth 1995, Poelt 1974, Clauzade and Roux 1985, Brodo at al. 2001) and are stored in the herbarium of Kazım Karabekir Faculty of Education, Atatürk University, Erzurum.

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RESULTS

Lobothallia alphoplaca (Wahlenb.) Hafellner
Thallus gray to brown, with radiating, very convex, 0.5-1.5 mm wide lobes, rather free from the substrate at the margins; lower surface pale. Apothecia abundant, superficial to immersed, dark red-brown; spores 10-16 x 6-10 µm. Growing on granite and sandstone. This species is distributed in temperate regions of the Northern hemisphere (Description in Brodo et al. 2001 and Poelt 1974).
Artvin: Murgul, Başköy village, in vicinity of Karşıyaka, on siliceous rock, at 650 m altitude, 41° 18' N, 41° 29' E, 21 June1999.

Peccania coralloides (A. Massal.) A. Massal.
Thallus up to 1cm in diameter, black like the apothecium, usually grayish-blue pruinose, upper surface of apothecium also usually pruinose. Apothecia up to 1 mm in diameter, with flat discs; spores globosely, 8-12 µm in diameter. Pycnospores fusiform. On calcareous rocks. This species is distributed in temperate regions of Eurasia. Usually in Mediterranean, Irano-Turanian, Saharo-Arabian and Sudanian territories (Descriptions in Poelt 1974, Clauzade and Roux 1985).
Erzurum: Çat, in vicinity of Yağmurcuk village, on calcareous rock, at 1850 m, 39° 46' N, 41° 07' E, 15 October.1999.

Pertusaria ocellata (Wallr.) Körb.
Thallus without isidia, sometimes with soralia, soralia not flat, wart-formed. Soralia, thallus and medulla more or less pale ash-gray, sometimes blackish, P -, K - or K + brownish. Saxicolous. This species is distributed in temperate regions of Europe (Description in Clauzade and Roux 1985).
Erzurum: Pasinler, Uzun ahmet village, in vicinity of Hamam dere, on siliceous rocks, at 1850 m altitude, 39° 58' N, 41° 26' E, 10 October.1999.

Toninia opuntioides (Vill.) Timdal
Thallus squamulose, squamulosa to 4 mm diameter, strongly convex to bullate when young, later vertically flattened and often imbricate; upper surface olivaceous brown to dark brown, usually partly white-pruinose (especially in convex parts) or sometimes not, slightly shiny, with shallow fissures in the cortex (when well developed), lacking pseudocyphellae; edge usually more densely white-pruinose; under surface white to pale brown; upper cortex 40-90 µm thick, including a thick epinecral layer to 50 µm, sometimes containing, or overlain by calcium oxalate crystals; lower cortex resembling the upper, thinner and lacking crystals. Photobiont layer continuous. Medulla lacking crystals. Apothecia to 4 mm diam.,weakly concave to weakly convex, usually moderately white-pruinose; true exciple distinct when young but later often excluded, medium to dark brown throughout or with a dark grey rim, K- and N- or K+ violet, N+ violet (grey pigment); epithecium grey, usually containing calcium oxalate crystals, K+ violet, N+ violet; hymenium 70-80 µm high, colourless, hypothecium medium brown in its lower part, dark brown in its upper part. Ascospores 12-25 x 3-5 µm, 1-septate, fusiform. On calcareous soil and rock, mainly among mosses or in fissures in rock walls. This species is distributed in temperate to subtropical regions of the Northern hemisphere (Descriptions in Purvis et al. 1994, Wirth 1995).
Artvin: Murgul, in vicinity of Akolşen, on calcareous rock, at 1000 m altitude, 41° 19'N, 41° 26' E, 20 June 1999.

Usnea chaetophora Stirton

Thallus longly pendent, to 30 cm, branches rather slender, 0.3-0.8 mm in diameter. Of equal thickness throughout much of their length, only narrowing towards the apices, often with annual cracks forming ± cylindrical segments which may become slightly swollen and narrowed towards their ends; branching frequent towards the base, less so towards the apices, fibrils rarely present, irregularly distributed, surface dark green, becoming darker in older parts, smooth, shining, with ±evenly scattered, white, punctate or comma-like tubercles which may become ulcerose and produce isidia, numerous low papillae in patches occasionally present on the main branches occasionally elongating into isidia; soralia, when present, distinctly tuberculate, punctiform, smaller than half the branch diameter; medulla ± lax, white. Medulla Pd + orange, K + red, C -. This species is distributed in temperate regions of the Northern hemisphere (Description in Purvis et al. 1992).

Giresun: Dereli, in vicinity of Kulakkaya, on *Fagus orientalis*, at 1550 m altitude, 40° 44' N, 38° 27' E, 25 September 1999.

DISCUSSION

Five species have been determined in this work, and all these species are new records for Turkey. Four of these spesices are crustose, and one is fructicose. In the previous studies conducted near the region, Aslan (2000) reported 201, Aslan et al. (2002) 94, Aslan and Öztürk (1994) 38, Yazıcı (1995) 10, Yazıcı and Aslan (2002a) 6 and Yazıcı and Aslan (2002b) 114 lichen species. Artvin and Giresun provinces, which a marine climate is present, are rich in lichen species diversity. Erzurum, which a continental climate is present, is poor in fruticose and foliose lichen species diversity, but rich in crustose lichen species. It is interesting that *Pertusaria ocellata*, a species known to be commonly distributed in temperate regions of Europe, is also present in Erzurum, where a long and cold winter runs.

We believe that this paper, and forthcoming papers of this line, will significantly contribute to the lichen flora of Turkey, which is not completely determined yet.

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We would like to thank Dr. Volker John who kindly confirmed the significance of two of reported species as first records for Turkey, Prof. Dr. Antonín Vĕzda who confirmed the identification of two species, and Dr. Harrie Sipman who reviewed the paper, for their valuable help and recommendations in the making of this paper.

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MYCOTAXON

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NEW TAIWAN MACROLICHENS

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Abstract: 58 macrolichens are reported new to Taiwan. Several represent considerable range extensions: *Polychidium stipitatum* and *Solenopsora elixiana* are reported for the first time for the Northern Hemisphere and several other species, e.g. the recently described *Rimelia pustulata,* appear to be new to (East) Asia.

Key words: lichenized, ascomycetes.

This paper presents new records of macrolichens for Taiwan, collected during a joint field trip in October 2001. As a baseline, we regard the checklist published in Lai (2000). However, this is partly based on the older literature. For instance, the Cladoniaceae of Taiwan were treated by Ahti & Lai (1979), but recent revisions, e.g. Stenroos (1998) lead to the identification of other species. For some genera, e.g. *Baeomyces, Cladonia, Dirinaria, Heterodermia, Leptogium, Peltigera,* and *Sticta,* not all older reports have been evaluated before new species are reported here. It cannot be totally ruled out that earlier records of other species in fact are referable to some of the taxa reported below as new. For several other groups where recent revisions are available, e.g. the Parmeliaceae (Kurokawa & Lai 2001) and the Stereocaulaceae (Lai 2001), the taxa below are undoubtedly never found before in Taiwan. Very recently, two additional species of *Usnea* have been published from Taiwan by Ohmura (2001). Several represent considerable range extensions: *Polychidium stipitatum* and *Solenopsora elixiana* are reported for the first time for the Northern Hemisphere; several other species, e.g. the recently described *Rimelia pustulata,* appear to be new to (East) Asia.

List of macrolichen species new to Taiwan

Baeomyces rufus (Huds.) Rebent.

Specimens examined: Taichung County: 15 km E of Taichung, garden with secondary forest remnants, 100 m. alt., 51RTG7873, on acid soil. *Sparrius 5817* (hb

Sparrius), 7 Oct. 2001. Miaoli County: Shei-Pa National Park. 25 km ENE of Tungshi, near Tahsuehshan, at km 48, 1600 m. alt., 51RTG996866, on soil. *Aptroot 51887 & 51890* (ABL), 8 Oct. 2001. Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on schistose rock. *Sparrius 5964* (hb Sparrius) *& Aptroot 51864* (ABL), 9 Oct. 2001. Same locality, soil and roots. *Aptroot 52205 & 52221* (ABL), 9 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on soil. *Aptroot 52702* (ABL), 11 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on shale. *Aptroot 52870* (ABL), 12 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, mountain pass, 3300 m. alt., 51RUG247705, on acid soil. *Sparrius 6304* (hb Sparrius), 13 Oct. 2001.

Candelaria concolor (Dicks.) Stein

Specimens examined: Taichung County: 15 km E of Taichung, garden with secondary forest remnants, 100 m. alt., 51RTG7873, on *Podocarpus. Aptroot 51625* (ABL), 7 Oct. 2001. Nantou County: 25 km ENE of Puli, Lushan, roadside, 1300 m. alt., 51RUG1557, on bark of *Magnolia grandiflora* near fern house. *Sparrius 6377* (hb Sparrius) *& Aptroot 52921* (ABL) 13 Oct. 2001.

Cladonia glauca Flörke

Specimen examined: Hualien County: Taroko National Park, Hohuan Shan, *Pseudotsuga* forest, 2950 m. alt., 51RUG231686, on *Pseudotsuga wilsoniana*. *Aptroot 52948* (ABL), 13 Oct. 2001.

TLC revealed squamatic acid.

Cladonia incrassata Flörke

Specimen examined: Hualien County: Taroko National Park, Hohuan Shan, roadside with relict mature trees, 3200 m. alt., 51RUG2572, on *Abies kawakamii* wood. *Aptroot 52824* (ABL), 13 Oct. 2001.

TLC revealed barbatic, squamatic and usnic acids.

Cladonia phyllopoda (Vain.) S. Stenroos

Specimens examined: Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on acid soil of roadbank. *Aptroot 52703* (ABL) *& Sparrius 6093* (hb Sparrius), 11 Oct. 2001.

A species restricted to tropical Asia and Oceania.

Cladonia strepsilis (Ach.) Grognot

Specimens examined: Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on acid soil. *Aptroot 52788* (ABL) *& Sparrius 6212* (hb Sparrius), 12 Oct. 2001.

TLC revealed squamatic acid and strepsilin.

Cladonia subsquamosa Krempelh.

Specimen examined: Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on soil. *Aptroot 52229* (ABL), 9 Oct. 2001.

TLC revealed fumarprotocetraric acid.

Cladonia umbricola Tønsberg & Ahti

Specimens examined: Nantou County: 15 km ENE of Puli, near Wushe, river gorge, 950 m. alt., 51RUG068562, on schistose rock. *Sparrius 5865* (hb Sparrius), 9 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, near Field Station, 3200 m. alt., 51RUG260725, on wood. *Aptroot 52607* (ABL) *& Sparrius 6182* (hb Sparrius), 12 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, *Pseudotsuga* forest, 2950 m. alt., 51RUG231686, on *Pseudotsuga wilsoniana*. *Aptroot 52937* (ABL), 13 Oct. 2001.

TLC revealed squamatic acid. So far known from Europe and America, but apparently new to Asia.

Dibaeis baeomyces (L. f.) Rambold & Hertel

Specimens examined: Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on acid soil. *Aptroot 52795* (ABL) *& Sparrius 6248, 6248* (hb Sparrius), 12 Oct. 2001.

Dibaeis pulogensis (Vain.) Kalb & Gierl

Common on roadbanks in Taiwan. Selected specimens examined: Miaoli County: Shei-Pa National Park. 27 km E of Tungshi, near Tahsuehshan, along forest track, 2600 m. alt., 51RUG000887, on soil. *Aptroot 51975* (ABL) *& Sparrius 5850* (hb Sparrius), 8 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, broadleaf forest remnant near field centre, 2100 m. alt., 51RUG1566, on schistose rock. *Aptroot 52476* (ABL) *& Sparrius 6089* (hb Sparrius), 11 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on acid soil. *Sparrius 6251* (hb Sparrius), 12 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, *Pseudotsuga* forest, 2950 m. alt., 51RUG231686, on soil. *Aptroot 52971 & 52900A* (ABL), 13 Oct. 2001. Nantou County: 25 km ENE of Puli, Lushan, roadside, 1300 m. alt., 51RUG1557, on clay of roadbank. *Sparrius 5441, 5442, 5443* (hb Sparrius), 13 Oct. 2001.

Dibaeis sorediata Kalb & Gierl

Specimens examined: Taichung County: 15 km E of Taichung, garden with secondary forest remnants, 100 m. alt., 51RTG7873, on sandstone. *Sparrius 5683* (hb Sparrius), 7 Oct. 2001. Same locality, on soil. *Aptroot 52663* (ABL), 7 Oct. 2001. Miaoli County: Shei-Pa National Park. 27 km E of Tungshi, near Tahsuehshan, along forest track, 2600 m. alt., 51RUG000887, on phyllite. *Sparrius 5848* (hb Sparrius), 8 Oct. 2001. Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on schistose rock. *Sparrius 5961* (hb Sparrius), 9 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, roadside with relict mature trees, 3200 m. alt., 51RUG2572, on soil. *Aptroot 52850* (ABL), 13 Oct. 2001. Taipei County: Yangmingshan National Park, along road 101A near park entrance, 350 m. alt., 51RUH494877, on soil of roadbank. *Sparrius 5242* (hb Sparrius), 23 Oct. 2001.

Dirinaria aegialita (Ach.) Moore

Specimen examined: Taichung County: 15 km E of Taichung, citrus garden, 450 m. alt., 51RTG794731, on sandstone boulders. *Aptroot 51717* (ABL), 7 Oct. 2001.

This species was incorrectly reported by Zahlbruckner (1933: 66), and therefore not cited by Lai (2000).

Dirinaria confluens (Fr.) Awashti

Specimens examined: Pingtung County: Kenting, 1 km N of Kenting village, 50 m. alt., 51QTE725290, on conglomaratic rock. *Sparrius 5295* (hb Sparrius), 17 Oct. 2001. Pingtung County: Kenting, near Frog Rock, 0-1 m. alt., 51QTE727276, on conglomeratic rock. *Aptroot 53363* (ABL), 18 Oct. 2001.

TLC revealed divaricatic acid.

Ephebe lanata (L.) Vain.

Specimens examined: Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on schistose rock. *Aptroot 52863* (ABL) *& Sparrius 6268* (hb Sparrius), 12 Oct. 2001.

Heterodermia microphylla (Kurok.) Skorepa

Specimens examined: Hualien County: 43 km WNW of Hualien, Meifeng, broadleaf forest remnant near field centre, 2100 m. alt., 51RUG1566, on schistose rock. *Aptroot 52472* (ABL) *& Sparrius 6086* (hb Sparrius), 11 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on *Castanopsis*. *Aptroot 52554* (ABL), 11 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, near Field Station, 3200 m. alt., 51RUG260725, on *Abies kawakamii*. *Sparrius 6155* (hb Sparrius), 12 Oct. 2001.

Heterodermia verrucifera (Kurok.) W.A. Weber

Specimens examined: Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on soil. *Aptroot 52709* (ABL), 11 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, near Field Station, 3200 m. alt., 51RUG260725, on *Abies kawakamii*. *Aptroot 52636* (ABL), 12 Oct. 2001.

Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt

Specimens examined: Taichung County: Taichung, park around Natural History Museum, 100 m. alt., 51RTG630735, on *Koelreuteria formosana*. *Aptroot 51570* (ABL), 6 Oct. 2001.Nantou County: 25 km ENE of Puli, Lushan, roadside, 1300 m. alt., 51RUG1557, on bark of *Magnolia grandiflora* near fern house. *Aptroot 52918* (ABL) *& Sparrius 6389* (hb Sparrius), 13 Oct. 2001. Same locality, on shale. *Aptroot 52929* (ABL), 13 Oct. 2001. Taichung County: 30 km ENE of Taichung, 7 km NW of Kukwan, along mountain trail, 1000-1300 m. alt., 51RTG9279, on *Ardisia sieboldii*. *Aptroot 53482A* (ABL) *& Sparrius 5163* (hb Sparrius), 20 Oct. 2001.

Hyperphyscia cochlearis Scutari

Specimens examined: Taichung County: Taichung, park around Natural History Museum, 100 m. alt., 51RTG630735, on *Erythrina variegata*. *Aptroot 51573* (ABL) *& Sparrius 5662* (hb Sparrius), 6 Oct. 2001. Chiai County: 15 km NNE of Chiai, wayside trees in agricultural area, 75 m. alt., 51QTG4715, on *Cinnamomum*. *Aptroot 53373* (ABL), 18 Oct. 2001. Taichung County: 30 km ENE of Taichung, 7 km NW of Kukwan, along mountain trail, 1000-1300 m. alt., 51RTG9279, on *Ardisia sieboldii*. *Aptroot 53476* (ABL), 20 Oct. 2001.

Hyperphyscia granulata (Poelt) Moberg

Specimens examined: Taichung County: 30 km ENE of Taichung, 7 km NW of Kukwan, along mountain trail, 1000-1300 m. alt., 51RTG9279, on *Ardisia sieboldii*. *Aptroot 53482* (ABL) *& Sparrius 6469* (hb Sparrius), 20 Oct. 2001.

New to Asia, but apparently pantropical. The material is typical, except for the absence of anthraquinone in the medulla.

Hypotrachyna rockii (Zahlbr.) Hale

Specimens examined: Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on *Cryptomeria*. *Aptroot 52169 & 52177* (ABL) *& Sparrius 5903* (hb Sparrius), 9 Oct. 2001. Taichung County: 30 km ENE of Taichung, 7 km NW of Kukwan, along mountain trail, 1000-1300 m. alt., 51RTG9279, on branch of *Shiia*. *Aptroot 53454* (ABL), 20 Oct. 2001.

TLC revealed lecanoric acid in all specimens cited. This species is sometimes incidentally confused with *H. revoluta* (Floerke) Hale, but that species was also observed among our material from Taiwan (e.g. Miaoli County: Shei-Pa National Park. 25 km ENE of Tungshi, near Tahsuehshan, at km 48, 1600 m. alt., 51RTG996866, on *Picea morrisonicola*. *Aptroot 51914* (ABL), 8 Oct. 2001).

Leioderma sorediatum D.J. Galloway & P.M. Jørg.

Specimens examined: Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on *Shiia calesii*. *Aptroot 52492* (ABL) *& Sparrius 6103* (hb Sparrius), 11 Oct. 2001.

Leptogium austroamericanum (Malme) Dodge

Specimens examined: Nantou County: 15 km ENE of Puli, near Wushe, river gorge, 950 m. alt., 51RUG068562, on schistose rock. *Aptroot 52073* (ABL) *& Sparrius 5863* (hb Sparrius), 9 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on shale. *Aptroot 52887* (ABL), 12 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, roadside with relict mature trees, 3200 m. alt., 51RUG2572, on soil. *Aptroot 52854* (ABL), 13 Oct. 2001. Nantou County: 25 km ENE of Puli, Lushan, roadside, 1300 m. alt., 51RUG1557, on shale. *Aptroot 52985* (ABL), 13 Oct. 2001. Pingtung County: 45 km SE of Kaohsiung, near Fangshan, rock outcrops, 20 m. alt., 51QTE626526, on conglomeratic rock. *Aptroot 53048* (ABL) *& Sparrius 5409* (hb Sparrius), 16 Oct. 2001. Pingtung County: Kenting Forest Recreation Area, near guesthouse, 200 m. alt., 51QTE743300, on *Ficus microcarpa*. *Aptroot 53207* (ABL), 17 Oct. 2001. Taichung County: 29 km E of Taichung, 6 km W of Kukwan, along a river, 750 m. alt., 51RTG926731, on quartzite, shaded. *Sparrius 5219* (hb Sparrius), 20 Oct. 2001.

Leptogium burnetiae Dodge

Specimens examined: Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on *Populus*. *Aptroot 52104* (ABL) *& Sparrius 5913* (hb Sparrius), 9 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, broadleaf forest remnant near field centre, 2100 m. alt., 51RUG1566, on *Shiia calesii*. *Aptroot 52452 & 52453* (ABL), 11 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on soil of roadbank. *Aptroot 52713 & 52714* (ABL) *& Sparrius 6097* (hb Sparrius), 11 Oct.

2001. Same locality, on *Castanopsis*. *Aptroot 52570* (ABL), 11 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, near Field Station, 3200 m. alt., 51RUG260725, on *Abies kawakamii*. *Sparrius 6149* (hb Sparrius), 12 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on mosses and acid rock. *Sparrius 6292, 6279* (hb Sparrius), 12 Oct. 2001. Taichung County: 30 km ENE of Taichung, 7 km NW of Kukwan, along mountain trail, 1000-1300 m. alt., 51RTG9279, on *Ficus nervosa*. *Aptroot 53470* (ABL), 20 Oct. 2001.

Leptogium corticola (Taylor) Tuck.

Specimens examined: Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on *Castanopsis*. *Aptroot 52569* (ABL), 11 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, *Pseudotsuga* forest, 2950 m. alt., 51RUG231686, on *Pseudotsuga wilsoniana*. *Aptroot 52944* (ABL), 13 Oct. 2001. Nantou County: 25 km ENE of Puli, Lushan, roadside, 1300 m. alt., 51RUG1557, on shale. *Aptroot 52987* (ABL), 13 Oct. 2001.

Leptogium denticulatum Malme

Specimens examined: Nantou County: 15 km ENE of Puli, near Wushe, river gorge, 950 m. alt., 51RUG068562, on schistose rock. *Aptroot 52081* (ABL) *& Sparrius 5871* (hb Sparrius), 9 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on *Castanopsis*. *Aptroot 52599* (ABL), 11 Oct. 2001. Nantou County: 25 km ENE of Puli, Lushan, roadside, 1300 m. alt., 51RUG1557, on shale. *Aptroot 52986* (ABL), 13 Oct. 2001.

Leptogium laceroides de Lesd.

Specimens examined: Hualien County: 43 km WNW of Hualien, Meifeng, broadleaf forest remnant near field centre, 2100 m. alt., 51RUG1566, on mature *Fatsia*. *Sparrius 6074* (hb Sparrius), 11 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on *Castanopsis*. *Aptroot 52566* (ABL), 11 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, near Field Station, 3200 m. alt., 51RUG260725, on *Tsuga formosana*. *Aptroot 52677* (ABL), 12 Oct. 2001.

Leptogium marginellum (Sw.) Mont.

Specimen examined: Pingtung County: Kenting Forest Recreation Area, near guesthouse, 200 m. alt., 51QTE743300, on *Delonix regia*. *Aptroot 53261* (ABL), 17 Oct. 2001.

Leptogium phyllocarpum (Pers.) Mont.

Specimens examined: Hualien County: 43 km WNW of Hualien, Meifeng, broadleaf forest remnant near field centre, 2100 m. alt., 51RUG1566, on mature *Fatsia*. *Sparrius 6073* (hb Sparrius), 11 Oct. 2001. Same locality, on mature *Shiia calesii*. *Aptroot 52456* (ABL) *& Sparrius 6061* (hb Sparrius), 11 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on *Castanopsis*. *Aptroot 52567* (ABL), 11 Oct. 2001.

Leptogium sessile Vain

Specimens examined: Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on *Cryptomeria*. *Sparrius 5897* (hb Sparrius), 9 Oct. 2001. Same locality, on *Populus*. *Aptroot 52125* (ABL) *& Sparrius 5937* (hb Sparrius), 9 Oct. 2001.

Peltigera cichoracea Jatta

A common species in Taiwan. Selected specimens examined: Taichung County: 20 km E of Tungshi, along road to Tahsuehshan at km 37, 1100 m. alt., 51RTG947814, on granite. *Aptroot 51764* (ABL), 8 Oct. 2001. Miaoli County: Shei-Pa National Park. 27 km E of Tungshi, near Tahsuehshan, along forest track, 2600 m. alt., 51RUG000887, on soil. *Aptroot 51978* (ABL), 8 Oct. 2001. Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on soil. *Aptroot 52217 & 52218* (ABL) *& Sparrius 5954* (hb Sparrius), 9 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, roadside with relict mature trees, 3200 m. alt., 51RUG2572, on soil. *Aptroot 52840* (ABL), 13 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, *Pseudotsuga* forest, 2950 m. alt., 51RUG231686, on *Pseudotsuga wilsoniana*. *Aptroot 52953* (ABL) *& Sparrius 6345* (hb Sparrius), 13 Oct. 2001.

Phaeophyscia hispidula (Ach.) Moberg s.s.

Specimens examined: Nantou County: 15 km ENE of Puli, near Wushe, river gorge, 950 m. alt., 51RUG068562, on shale. *Aptroot 52082* (ABL), 9 Oct. 2001. Nantou County: 44 km WNW of Hualien, Meifeng, broadleaf forest remnant in valley, 2050 m. alt., 51RUG146655, on *Macula*. *Sparrius 6028* (hb Sparrius), 10 Oct. 2001. Same locality, on *Skimma superba*. *Aptroot 52262* (ABL), 10 Oct. 2001. Nantou County: 25 km ENE of Puli, Lushan, roadside, 1300 m. alt., 51RUG1557, on shale. *Sparrius 6391* (hb Sparrius), 13 Oct. 2001.

Phaeophyscia limbata (Poelt) Kashiw.

Specimens examined: Taichung County: 15 km E of Taichung, citrus garden, 450 m. alt., 51RTG794731, on sandstone. *Aptroot 51718* (ABL), 7 Oct. 2001. Taichung County: 10 km S of Tungshi, on bridge over Dajia Shi river, 300-400 m. alt., 51RTG803750, on concrete. *Aptroot 51745* (ABL), 8 Oct. 2001. Taichung County: 22 km E of Tungshi, Tahsuehshan Forest Recreation Area, near entrance, 1500 m. alt., 51RTG9482, on *Cryptomeria*. *Aptroot 51811* (ABL), 8 Oct. 2001. Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on *Populus*. *Sparrius 5920* (hb Sparrius), 9 Oct. 2001. Nantou County: 44 km WNW of Hualien, Meifeng, broadleaf forest remnant in valley, 2050 m. alt., 51RUG146655, on *Castanopsis*. *Aptroot 52317* (ABL), 10 Oct. 2001. Nantou County: 25 km ENE of Puli, Lushan, roadside, 1300 m. alt., 51RUG1557, on shale. *Aptroot 52932* (ABL), 13 Oct. 2001.

Phaeophyscia primaria (Poelt) Trass

Specimens examined: Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on *Castanopsis*. *Aptroot 52596* (ABL) *& Sparrius 6098* (hb Sparrius), 11 Oct. 2001.

Phaeophyscia trichophora (Hue) Essl.

Specimen examined: Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on *Populus*. *Aptroot 52115* (ABL), 9 Oct. 2001.

Physcia atrostriata Moberg

A very common species in Taiwan. Selected specimens examined: Taichung County: Taichung, park around Natural History Museum, 100 m. alt., 51RTG630735, on *Chionantus retusus*. *Aptroot 51572* (ABL) *& Sparrius 5658* (hb Sparrius), 6 Oct. 2001. Same locality, on *Koelreuteria formosana*. *Aptroot 51571* (ABL) *& Sparrius 5654* (hb Sparrius), 6 Oct. 2001. Taichung County: 15 km E of Taichung, garden with secondary forest remnants, 100 m. alt., 51RTG7873, on bark of *Diospyros kaki*. *Sparrius 5710* (hb Sparrius), 7 Oct. 2001. Same locality, on *Cinnamomum*. *Aptroot 51605* (ABL), 7 Oct. 2001. Taichung County: 15 km E of Taichung, citrus garden, 450 m. alt., 51RTG794731, on sandstone boulders. *Aptroot 51703* (ABL) *& Sparrius 5461 & 5735* (hb Sparrius), 7 Oct. 2001. Pingtung County: 45 km SE of Kaohsiung, near Fangshan, rock outcrops, 20 m. alt., 51QTE626526, on conglomeratic rock. *Aptroot 53042* (ABL), 16 Oct. 2001. Pingtung County: Kenting Forest Recreation Area, near guesthouse, 200 m. alt., 51QTE743300, on *Roystonea regia*. *Aptroot 53239* (ABL), 17 Oct. 2001. Chiai County: 15 km NNE of Chiai, wayside trees in agricultural area, 75 m. alt., 51QTG4715, on *Cinnamomum*. *Aptroot 53375* (ABL) *& Sparrius 5267* (hb Sparrius), 18 Oct. 2001. Taichung County: 30 km E of Taichung, 5 km W of Kukwan, along the road, 700 m. alt., 51RTG929745, on shale. *Aptroot 53533 & 53536* (ABL) *& Sparrius 5230* (hb Sparrius), 20 Oct. 2001. Taipei County: 25 km N of Taipei, seashore, volcanic rock outcrop near Sanji, 0-5 m. alt., 51RUH501977, on volcanic rock. *Aptroot 53593* (ABL) *& Sparrius 5499* (hb Sparrius), 22 Oct. 2001.

Physcia melanchra Hue

Specimens examined: Taichung County: 30 km E of Taichung, 5 km W of Kukwan, along the road, 700 m. alt., 51RTG929745, on slate. *Sparrius 5226* (hb Sparrius), 20 Oct. 2001. Taipei County: 25 km N of Taipei, seashore, volcanic rock outcrop near Sanji, 0-5 m. alt., 51RUH501977, on volcanic rock. *Aptroot 53594* (ABL), 22 Oct. 2001.

Physcia sorediosa (Vain.) Lynge

A very common species in Taiwan. Selected specimens examined: Taichung County: 15 km E of Taichung, garden with secondary forest remnants, 100 m. alt., 51RTG7873, on sandstone. *Aptroot 51670* (ABL), 7 Oct. 2001. Taichung County: 15 km E of Taichung, citrus garden, 450 m. alt., 51RTG794731, on sandstone boulders. *Aptroot 51505 & 51732* (ABL) *& Sparrius 5460* (hb Sparrius), 7 Oct. 2001. Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on *Populus*. *Aptroot 52117* (ABL), 9 Oct. 2001. Nantou County: 44 km WNW of Hualien, Meifeng, broadleaf forest remnant in valley, 2050 m. alt., 51RUG146655, on *Castanopsis*. *Aptroot 52304* (ABL), 10 Oct. 2001. Pingtung County: 45 km SE of Kaohsiung, near Fangshan, rock outcrops, 20 m. alt., 51QTE626526, on conglomeratic rock. *Aptroot 53054* (ABL), 16 Oct. 2001. Pingtung County: Kenting, 1 km N of Kenting village, 50 m. alt., 51QTE725290, on conglomeratic rock. *Aptroot 53088* (ABL), 17 Oct. 2001. Pingtung County: Kenting, near Frog Rock, 0-1 m. alt., 51QTE727276, on conglomeratic rock. *Aptroot 53360 & 53370* (ABL), 18 Oct. 2001. Taichung County: 30 km ENE of Taichung, 7 km NW of Kukwan, along mountain trail, 1000-1300 m. alt., 51RTG9279, on shale. *Aptroot 53428 & 53429* (ABL), 20 Oct. 2001. Same locality, on *Ficus nervosa*. *Aptroot 53467* (ABL), 20 Oct. 2001.Taipei County: 25 km N of Taipei, seashore, volcanic rock outcrop near Sanji, 0-5 m. alt., 51RUH501977, on volcanic rock. *Aptroot 53580 & 53592* (ABL), 22 Oct. 2001.

Physconia muscigena (Ach.) Poelt

Specimens examined: Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on schistose rock. *Sparrius 6278* (hb Sparrius), 12 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, roadside with relict mature trees, 3200 m. alt., 51RUG2572, on bark of *Abies*. *Sparrius 6322* (hb Sparrius), 13 Oct. 2001. Same locality, on soil. *Aptroot 52843* (ABL), 13 Oct. 2001.

On all localities mentioned, this species was growing side-by-side with the endemic *Physconia tentaculata* (Zahlbr.) Poelt, which differs by the much more dissected lobes and the darker green colour.

Polychidium stipitatum Vezda & W. A. Weber

Specimens examined: Taichung County: 22 km E of Tungshi, Tahsuehshan Forest Recreation Area, near entrance, 1500 m. alt., 51RTG9482, on mature deciduous tree. *Sparrius 6474* (hb Sparrius), 8 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on *Castanopsis*. *Aptroot 52366* (ABL), 11 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, near Field Station, 3200 m. alt., 51RUG260725, on *Tsuga formosana*. *Aptroot 52675* (ABL) *& Sparrius 6167* (hb Sparrius), 12 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on soil. *Aptroot 52780* (ABL), 12 Oct. 2001.

These represent the first records from the Northern Hemisphere of this species, which was described from Papua New Guinea, where it is fairly common. See for the diagnostic characters Aptroot et al. (1997).

Pseudocyphellaria crocata (L.) Vain. s.s.

Specimen examined: Hualien County: Taroko National Park, Hohuan Shan, near Field Station, 3200 m. alt., 51RUG260725, on *Abies kawakamii*. *Aptroot 52618* (ABL), 12 Oct. 2001.

Pseudocyphellaria desfontainii (Delise) D.J. Galloway

Specimen examined: Hualien County: 43 km WNW of Hualien, Meifeng, broadleaf forest remnant near field centre, 2100 m. alt., 51RUG1566, on *Shiia calesii*. *Aptroot 52465* (ABL), 11 Oct. 2001.

Psora nipponica (Zahlbr.) Gotth. Schneider

Specimen examined: Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on soil. *Aptroot 52847* (ABL), 11 Oct. 2001.

Pyxine berteriana (Fée) Imshaug

Specimen examined: Pingtung County: Kenting Forest Recreation Area, forest reserve, 200 m. alt., 51QTE745307, on *Acacia confusa*. *Aptroot 53149* (ABL), 16 Oct. 2001.

Pyxine consocians Vain. s.s.

Specimen examined: Pingtung County: Kenting, near Frog Rock, 0-1 m. alt., 51QTE727276, on conglomeratic rock. *Aptroot 53345* (ABL), 18 Oct. 2001.

This species has often been confused with *P. copelandii* Vain., but this species was also present in our material from Taiwan (e.g. Pingtung County: Kenting Forest Recreation Area, near guesthouse, 200 m. alt., 51QTE743300, on *Ficus*. *Aptroot 53188* (ABL), 17 Oct. 2001).

Pyxine cylindrica Kashiw.

Specimens examined: Pingtung County: Kenting Forest Recreation Area, near guesthouse, 200 m. alt., 51QTE743300, on *Schefflera*. *Aptroot 53254* (ABL), 17 Oct. 2001. Pingtung County: Kenting, 1 km N of Kenting village, 50 m. alt., 51QTE725290, on conglomeratic rock. *Aptroot 53314* (ABL), 17 Oct. 2001. Pingtung County: Kenting, near Frog Rock, 0-1 m. alt., 51QTE727276, on conglomeratic rock. *Aptroot 53367* (ABL), 18 Oct. 2001.

Pyxine himalayensis D.D. Awasthi

Specimens examined: Nantou County: 44 km WNW of Hualien, Meifeng, broadleaf forest remnant in valley, 2050 m. alt., 51RUG146655, on *Michelia formosana*. *Aptroot 52269* (ABL), 10 Oct. 2001. Nantou County: 45 km WNW of Hualien, Meifeng, broadleaf forest remnant on ridge, 2050 m. alt., 51RUG145645, on *Pisana*. *Aptroot 52335* (ABL), 10 Oct. 2001.

Pyxine petricola Nyl.

Specimens examined: Taichung County: 30 km E of Taichung, 5 km W of Kukwan, along the road, 700 m. alt., 51RTG929745, on shale. *Aptroot 53531* (ABL) *& Sparrius 5236* (hb Sparrius), 20 Oct. 2001.

Ramalina seawardii Aptroot & Sipman

Specimens examined: Taipei County: 25 km N of Taipei, seashore, volcanic rock outcrop near Sanji, 0-5 m. alt., 51RUH501977, on volcanic rock. *Aptroot 53581* (ABL) *& Sparrius 5500* (hb Sparrius), 22 Oct. 2001.

This species was so far known from Hong Kong and Kinmen, a tiny island just off the Chinese coast that politically belongs to Taiwan (Aptroot & Sipman 2001).

Rimelia pustulata Elix & Bawingan

Specimens examined: Taichung County: 22 km E of Tungshi, Tahsuehshan Forest Recreation Area, near entrance, 1500 m. alt., 51RTG9482, on mature deciduous tree. *Sparrius 5759* (hb Sparrius), 8 Oct. 2001. Same locality, on *Cryptomeria*. *Aptroot 51809* (ABL), 8 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on *Shiia calesii*. *Aptroot 52494* (ABL), 11 Oct. 2001.

New to the temperate East Asia. So far only known from Australai and the Philippines. TLC revealed salazinic acid.

Solenopsora elixiana Verdon & Rambold

Specimens examined: Taichung County: 15 km E of Taichung, citrus garden, 450 m. alt., 51RTG794731, on sandstone boulders. *Aptroot 51501*(ABL) *& Sparrius 5470 & 5728* (hb Sparrius), 21 Oct. 2001. Nantou County: 25 km ENE of Puli, Lushan, roadside, 1300 m. alt., 51RUG1557, on shale. *Aptroot 52934* (ABL) *& Sparrius 6395* (hb Sparrius), 13 Oct. 2001.

New to the Northern Hemisphere. So far known only from Australia.

Stereocaulon pileatum Ach.

Rather common but so far overlooked in Taiwan. Selected specimens examined: Taichung County: 20 km E of Tungshi, along road to Tahsuehshan at km 37, 1100 m. alt., 51RTG947814, on granite. *Aptroot 51759* (ABL), 8 Oct. 2001. Miaoli County: Shei-Pa National Park. 27 km E of Tungshi, near Tahsuehshan, along forest track, 2600 m. alt., 51RUG000887, on phyllite. *Sparrius 5847* (hb Sparrius), 8 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, roadside with relict mature trees, 3200 m. alt., 51RUG2572, on schistose rock. *Sparrius 6332* (hb Sparrius), 13 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, *Pseudotsuga* forest, 2950 m. alt., 51RUG231686, on shale. *Aptroot 52969* (ABL) *& Sparrius 6373* (hb Sparrius), 13 Oct. 2001. Taipei County: Yangmingshan National Park, along road 101A near park entrance, 350 m. alt., 51RUH494877, on volcanic rock. *Aptroot 53627* (ABL), 23 Oct. 2001.

Sticta filicina Ach.

Specimens examined: Nantou County: 15 km ENE of Puli, near Wushe, river gorge, 950 m. alt., 51RUG068562, on *Machilus thunbergii*. *Aptroot 52032* (ABL), 9 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, broadleaf forest remnant near field centre, 2100 m. alt., 51RUG1566, on mature *Fatsia*. *Sparrius 6075* (hb Sparrius), 11 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, near Field Station, 3200 m. alt., 51RUG260725, on *Abies kawakamii*. *Aptroot 52628A* (ABL), 12 Oct. 2001.

Sticta orbicularis (Braun) Hue

Specimens examined: Nantou County: 44 km WNW of Hualien, Meifeng, broadleaf forest remnant in valley, 2050 m. alt., 51RUG146655, on *Machilus thunbergii*. *Sparrius 6016* (hb Sparrius), 10 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, near Field Station, 3200 m. alt., 51RUG260725, on *Abies kawakamii*. *Aptroot 52628* (ABL), 12 Oct. 2001.

Sticta platyphylloides Nyl.

Specimen examined: Nantou County: 44 km WNW of Hualien, Meifeng, broadleaf forest remnant in valley, 2050 m. alt., 51RUG146655, on *Skimma superba*. *Aptroot 52263* (ABL), 10 Oct. 2001.

Sticta sylvatica (Huds.) Ach.

Specimens examined: Nantou County: 45 km WNW of Hualien, Meifeng, around field centre, 2000-2100 m. alt., 51RUG1464, on *Populus*. *Aptroot 52126* (ABL), 9 Oct. 2001. Hualien County: 43 km WNW of Hualien, Meifeng, broadleaf forest remnant near field centre, 2100 m. alt., 51RUG1566, on mature *Fatsia*. *Sparrius 6076* (hb Sparrius), 11 Oct. 2001.

Usnea fragilescens Havaas ex Lynge

Specimens examined: Miaoli County: Shei-Pa National Park. 25 km ENE of Tungshi, near Tahsuehshan, at km 48, 1600 m. alt., 51RTG996866, on *Pinus*. *Sparrius 5802* (hb Sparrius), 8 Oct. 2001. Same locality, on *Picea morrisonicola*. *Aptroot 51925* (ABL), 8 Oct. 2001. Hualien County: Taroko National Park, Hohuan Shan, exposed mountain ridge, 3000 m. alt., 51RUG2673, on twig of *Rhododendron*. *Aptroot 52905* (ABL) *& Sparrius 6284* (hb Sparrius), 12 Oct. 2001.

This species was not mentioned by Ohmura (2001) for Taiwan.

Usnea mutabilis Stirt.

Specimen examined: Hualien County: 43 km WNW of Hualien, Meifeng, roadside with relict mature trees, 2250 m. alt., 51RUG1666, on mature *Castanopsis*. *Sparrius 6115* (hb Sparrius), 11 Oct. 2001.

This species was not mentioned by Ohmura (2001) for Taiwan.

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ON LICHENICOLOUS FUNGI FROM NORTH AMERICA. II.

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Abstract. An annotated list of 70 taxa of lichenicolous fungi (56 Ascomycetes, 3 Basidiomycetes, 8 Coelomycetes and 3 Hyphomycetes) from North America is documented. *Dactylospora pleiosperma*, *Endococcus oreinae*, *Plectocarpon nashii*, and *Stigmidium epixanthum* are new to science. Whereas *Dactylospora pleiosperma*, *Endococcus oreinae*, *Plectocarpon nashii* are so far only known from restricted areas in North America, *Stigmidium epixanthum* is a widespread species. Each treated taxon represents a new record to either one of the states of the U.S.A. or one of the provinces of Canada or Mexico or Greenland. 25 of these are new records for entire or continental North America. *Buelliella inops* is a new combination. In addition the lichenized *Leucocarpia biatorella*, found as admixture in a specimen of *Arthonia peltigerea*, is reported for the first time from Colorado.

Keywords: Ascomycetes, Coelomycetes, Hyphomycetes, Basidiomycetes, Canada, United States of America, Mexico, Greenland.

Introduction

Previous contributions to the knowledge of lichenicolous fungi in North America have been summarized by Triebel et al. (1991) and Alstrup & Cole (1998). This is a follow-up article to the one by Triebel et al. (1991), reporting on new lichenicolous fungi from North America. Triebel et al. (1991) were able to raise the number of lichenicolous fungi known from this continent to 120. Since then a number of additional taxa and for many species extensions of distribution range have been published by Alstrup & Cole (1998), Alstrup & Hansen (2001), Alstrup et al. (2000), Aptroot et al. (1997), Atienza & Hawksworth (1994), Cole & Hawksworth (2001), Coppins & Kondratyuk (1998), Diederich & Etayo (2000), Diederich & Zhurbenko (2001), Esslinger & Egan (1995), Etayo & Breuss (1998, 2001), Etayo & Diederich (1996), Geiser et al. (1998), Gierl & Kalb (1993), Hafellner (1993, 1994, 1995, 1999, 2001), Hafellner & Calatayud (1999), Hansen (1998, 2001), Hansen & Alstrup (1995), Hansen & Obermayer (1999), Harris (1995), Hawksworth & Esslinger (1993), Hawksworth & Kalb (1992), Hawksworth & Santesson (1990), Hoffmann & Hafellner (2000), Horáková & Alstrup (1994), Kalb et al. (1995), Kocourková (2000), Kondratyuk (1996), Kondratyuk & Galloway (1995), Kümmerling et al. (1993), Lowen (1995), Matzer et al. (1996), Navarro-Rosinés & Hafellner (1996), Navarro-Rosinés & Etayo (2001), Navrotskaya et al. (1996), Peterson & Rikkinen (1999), Rossman et al. (1999), Roux & Triebel (1994), Santesson (1994, 1998, 2001), Santesson & Tønsberg (1994), Selva (1998), Selva & Tibell (1999), Thomson (1995), Tibell & Ryman (1995), Triebel (1999), Triebel et al. (1995, 1997), Wetmore (1999), Will-Wolf (1998), and Zhurbenko et al. (1995).

Each of the species listed below represents a new record for one of the states of U.S.A. (mostly Arizona) or Mexico, or one of the provinces of Canada. One species represents a new record to Greenland. In some cases the record may only be formally new, as some of the species were previously included in others by the application of a wider species concept.

Material and Methods

Dried herbarium specimens cited together with the treatments of the species have been used. External morphology and microscopical features were studied by mycological routine methods. Preparations were mounted in water. When necessary, contrasting was performed by a pretreatment with lactic acid-cotton blue (MERCK 13741). Amyloid reactions in hymenia were observed by the use of Lugol's reagent (MERCK 9261). Conidiogenesis was studied in erythrosin B (ALDRICH 19,826-9) in 10% ammonia. Sections and squash preparations were not pretreated with K, unless otherwise stated. Measurements refer to dimensions in tap water.

Besides specific literature the keys published by Clauzade et al. (1989) and Hawksworth (1983) were used for determination work. As far as possible species nomenclature follows Esslinger & Egan (1995). Author abbreviations are those proposed by Brummitt & Powell (1992). Abbreviations for institutional herbaria follow Holmgren et al. (1990), for exsiccata abbreviations see Triebel & Scholz (2001–2002).

Abbreviations:

H. = J. Hafellner, N. = T.H. Nash III, T. = D. Triebel, LM = under light microscope, N. F. = National Forest, N. P. = National Park, I = Lugol, KI = Lugol after pretreatment with potassium hydroxide, K = potassium hydroxide solution.

Sel. lit.: = selected literature. In this paragraph we give both references to a publication including a description of the taxon and, after a semicolon, to papers that report previous North-American records.

* Species that are reported here for the U.S.A. or Canada and are not listed in Esslinger (1997–2001; online tested 30th January 2002) are marked by an asterisk following "North America" in the paragraph summing up the overall distribution.

The Species

Abrothallus peyritschii (Stein) C.Kotte (Ascomycetes: ? Arthoniales)

This species which is restricted to *Vulpicida* species was discussed by Triebel et al. (1991), who reported it from Alberta.

Distribution: Europe, Asia (Georgia), Australasia (New Zealand) and North America (Canada, U.S.A.). New to Arizona.

Sel. lit.: Clauzade et al. (1989), Kotte (1909); Triebel et al. (1991), Cole & Hawksworth (2001).

Specimen: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, between Phelp's cabin and base of cliffs, mixed conifer forest including large *Pseudotsuga menziesii*, 33°55'30"N, 109°30'30"W, ca. 2800 m, on bark of *P. menziesii*, on *Vulpicida pinastri* (thallus), H. 36657 (GZU).

Abrothallus usneae Rabenh. (Ascomycetes: ? Arthoniales)

In one of the collections (N. 34739) all ascomata have developed on the basidiocarps of *Biatoropsis usnearum* on *Usnea*. In the United States it was previously reported from Colorado (Fink 1935) but this record is *Lichenostigma maureri* Hafellner (compare Esslinger & Egan 1995: 539). Recently the existence of *Abrothallus usneae* in North America was confirmed by Cole & Hawksworth (2001) with a collection from Minnesota.
Distribution: Europe, Africa (Macaronesia, Madagascar), Asia (Turkey, Mongolia, Papua New Guinea), North America (U.S.A.). New to Arizona.
Sel. lit.: Stein (1879); Fink (1935, sub *Buelliella usneae*), Cole & Hawksworth (2001).

Specimens: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, along Hall Creek, *Picea engelmannii–Abies lasiocarpa* forest, 33°57'30"N, 109°32'W, ca. 2750 m, on twigs of *P. engelmannii*, on *Usnea* sp. (thallus), H. 36600 (herb. Hafellner). Ibid., on *Usnea* cf. *fulvoreagens* (in basidiocarps of *Biatoropsis usnearum*, together with the *Vouauxiomyces* anamorph), N. 34739 (ASU).

Arthonia clemens (Tul.) Th.Fr. s. str. (Ascomycetes: Arthoniales)

Arthonia clemens was discussed by Triebel et al. (1991). Following a narrower species concept only the specimen from New Mexico mentioned there belongs to *A. clemens* in the strict sense. For the specimens from Colorado and Arizona (on *Lecanora dispersa*) *Arthonia apotheciorum* (A.Massal.) Almq. might be a suitable name (see Triebel & Scholz 2001). All specimens mentioned below are on *Rhizoplaca chrysoleuca* (hymenia).
Distribution: Europe, Asia (Turkey, Russia, China), and North America (U.S.A., Greenland). New to Arizona.
Sel. lit.: Tulasne (1852); Triebel et al. (1991), Hafellner (1995).

Specimens: **U.S.A. Arizona.** Apache Co.: Apache N. F., NE of Big Lake, by the main forest service road (113), open rocky area with scattered trees, on boulders of volcanic rocks exposed to the W, 33°53'40"N, 109°24'30"W, ca. 2620 m, H. 36632 (GZU). Mt. Baldy Wilderness, between Phelp's cabin and base of cliffs, mixed conifer forest including large trees of *Pseudotsuga menziesii*, 33°55'30"N, 109°30'30"W, ca. 2800 m, on boulders of volcanic conglomerate at the edge of forest, H. 36641 (GZU). Summit of Mt. Baldy, 33°54'30"N, 109°34'W, ca. 3400 m, on basaltic cliffs exposed to NE, H. 36683 (GZU). 13 km N of Spingerville by Hwy 180, ca. 4 km S of intersection with county road 4162, 34°14'45"N, 109°20'30"W, ca. 1900 m, outcrops of lava flow in a pasture, on volcanic rock exposed to NW, H. 36835 (GZU). Coconino Co.: Coconino N. F., N of Mt. Humphries, at junction of Albineau and Bear Jaw Trails near tree line, 35°21'43"N, 111°40'25", 3040 m, on exposed boulders, Schramm 264 & Timdal (ASU). Coconino N. F., San Francisco Peaks, at junction of Albineau Trail and Bear Jaw Trail, 35°21'00''N, 111°40'25''W, 3040 m alt., *Abies* and *Pinus* forest adjacent to tree line, on acidic rock, Schramm 232c & Timdal, (separated from Lich. Exs. distr. Arizona State Univ. 336) (GZU). **New Mexico.** W of Los Alamos, by the road to Jemez Springs at the eastern border of Santa Fe N. F., ca. 2700 m, Kordesch & Pongratz (herb. Hafellner 1475).

Arthonia epiphyscia Nyl. (Ascomycetes: Arthoniales)

Triebel et al. (1991) previously reported this species as new for Arizona. Following the revised species concept of Grube & Matzer (1997) this record has to be assigned to *Arthonia phaeophysciae* Grube & Matzer. The records cited below represent therefore the first of *A. epiphyscia* s. str. for continental North America.
Distribution: Europe, Africa (Canary Islands, Marocco, South Africa), Asia (Russia), Australasia (New Zealand), the Antarctic island Bouvetøya, South America (Argentina, Chile), and North America (U.S.A., Mexico, Greenland). New to continental North America (U.S.A.: Arizona, Mexico).
Sel. lit.: Santesson (1960), Grube & Matzer (1997); Alstrup & Hawksworth (1990).

Specimens: **U.S.A. Arizona.** Coconino Co. west side of San Francisco Peaks, near road to Snow Bowl, 2680 m, on volcanic rock, together with *Stigmidium pumilum* on *Physcia wainioi* (thallus), N. 7472 (GZU). San Francisco Peaks N of Flagstaff, Coconino N. F., north side of Humphries Peak, along Abineau Trail, in mixed conifer forest, 35°23'N, 111°40'20"W, ca. 2650 m, on twigs of *Abies lasiocarpa*, on *Physcia stellaris* (thallus), H. 36852 (herb. Hafellner), H. 55278 (GZU). **Mexico. Sonora.** Sierra Madre Occidental, mountain ridge W of Yécora by the road (Hwy 16) to San Nicolás, N-facing slope with *Pinus–Quercus* forest and large rhyolite outcrops, 28°22'45"N, 109°02'20"W, ca. 1900 m, on *Physcia* sp. (thallus) on outcrops exposed to NE, H. 39307 (GZU).

Arthonia excentrica Th.Fr. (Ascomycetes: Arthoniales)

The lichenicolous growth of this species was for a long time not correctly understood. It is restricted to *Lepraria* and *Leprocaulon* species.
Distribution: Europe, Asia (Russia), South America (Peru), North America* (U.S.A., Greenland). New to continental North America (U.S.A.: Oregon).
Sel. lit.: Almquist (1880); Alstrup & Hawksworth (1990).

Specimen: **U.S.A. Oregon.** Klamath Co.: Fremont N. F., near junction of Forest Service roads 34 and 335, 8 km ESE of Bly, scabflat with sagebrush, 42°25'N, 120°56'30"W, 1425 m, on *Lepraria* cf. *neglecta* (thallus), Ryan 27906 (ASU).

Arthonia molendoi (Heufl. ex Frauenf.) R.Sant. (Ascomycetes: Arthoniales)

This species is characterized by the black ascomata 0.1–0.3 mm diam., pale hypothecium, distinct paraphyses, I+ wine red reaction of the hymenium without pretreatment with K, the black epithecium, and 1-septate ascospores 10–11 x 5 μm, with unequal cells. It has been found on species of *Caloplaca* and *Xanthoria.*
Distribution: Europe, Africa (Canary Islands), Asia (Lebanon, Israel), Australasia (New Zealand), Antarctica, North America (Canada, U.S.A., Greenland). New to Arizona.
Sel. lit.: Alstrup & Hawksworth (1990), Goward et al. (1996), Alstrup & Cole (1998), Cole & Hawksworth (2001).

Specimen: **U.S.A. Arizona.** Graham Co.: E side of the Pinaleno Mts, along trail above Shannon Campground, mixed conifer–oak forest, 32°39'N, 109°49'W, 2000 m, on *Xanthoria fallax* (thallus) N. 36091 (ASU).

Arthonia peltigerea Th.Fr. (Ascomycetes: Arthoniales)

The species is highly charcteristic by its large, convex, blackish ascomata. It is found damaging the thalli on both *Peltigera* and *Solorina*. One of the specimens cited below has characteristic *Leucocarpia biatorella* Vezda beside the infested squamules of *Solorina*. This verrucarialean lichen has been reported so far from continental North America only from New Mexico (Buck & Harris 2001).
Distribution: Europe, Asia (Russia), North America (U.S.A., Greenland). New to Colorado.
Sel. lit.: Almquist (1880); Santesson (1994).

Specimen: **U.S.A., Colorado.** Clear Creek Co.: Rocky Mountains, extensive N-facing talus development 1.9 km W of Silver Plume, 39°41'30"N, 105°44'W, 2845–2900 m, on *Solorina* sp. (thallus), Poelt (GZU, 2 specimens, one of them filed under *Leucocarpia biatorella*).

Arthonia phaeophysciae Grube & Matzer (Ascomycetes: Arthoniales)

The differences between the two lichenicolous *Arthonia* species with ascomata lacking a K+ purple reaction, growing on *Physcia* and *Phaeophyscia* have recently been pointed out by Grube & Matzer (1997). At least one earlier record of *Arthonia epiphyscia* (Triebel et al. 1991) from Arizona should belong here.
Distribution: Europe, North America (Canada, U.S.A., Greenland). New to Canada and California.
Sel. lit.: Grube & Matzer (1997); Alstrup & Hawksworth (1990, sub *A. molendoi*, p. p.), Triebel et al. (1991, sub *A. epiphyscia*, p.p.).

Specimens: **Canada. British Columbia.** Marble Canyon Provincial Park, dry limestone cliffs, 50°50'N, 121°40'W, ca. 600 m, on *Phaeophyscia* sp. (thallus), Goward & Poelt (GZU). U.S.A. California. Santa Barbara Co.: Santa Cruz Island, central valley ca. 1 mile W of Univ. of California Research Station, on exposed roots of *Quercus*, on *Phaeophyscia cernohorskyi* (thallus), Weber & Bratt (GZU).

Athelia arachnoidea (Berk.) Jülich (Basidiomycetes: Poriales).

Athelia arachnoidea is an aggressive parasite on a wide range of foliose and crustose lichens mostly growing on bark. Jülich (1972: 60) cited several collections from Canada and U.S.A. However, lichenicolous growth was not indicated in these cases. Adams & Kropp (1996) used non-lichenicolous specimens from Oregon, when they established the teleomorph–anamorph connection with *Rhizoctonia carotae* Rader.
Distribution: Europe, Africa (Tunisia), South America, North America* (Canada, U.S.A.). New to Arizona.
Sel. lit.: Jülich (1972), Adams & Kropp (1996).

Specimen: **U.S.A. Arizona.** Coconino Co.: Coconino N. F., canyon of the West Fork of Oak Creek SW of Flagstaff, vicinity of West Buzzard Point, mixed conifer forest, 35°02'N, 111°51'W, ca. 1900 m, on bark of *Quercus gambelii*, on *Physcia aipolia* (thallus), H. 36878 (GZU).

Biatoropsis usnearum Räsänen (Basidiomycetes: Platygloeales)

This species is characterized by formation of pale pinkish to reddish brown, dark brown or black, convex galls ("carpoids") 0.2–2.5 mm wide, often on the branch tips of the host. The basidia are auricularioid, 20–44 µm long, of one part, claviform, with

elongate epibasidia almost parallel to the basidium; the apiculus is lateral and non-refractive. All specimens are on *Usnea*.
Distribution: Europe, Africa, Asia, Australasia, South America, North America (Canada, U.S.A., Mexico). New to Mexico.
Sel. lit.: Diederich (1996), Diederich & Christiansen (1994); Goward et al. (1994), Alstrup & Cole (1998), Etayo & Breuss (1998), Triebel (1999).

Specimens. **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, trail from Phelp's Creek, 33°55'30"N, 109°31'W, 3000 m, on *Usnea hirta* (det. N.), Ryan & N. 26893 (with *Phaeosporobolus usneae*) (ASU). Mt. Baldy Wilderness, along Hall Creek, *Picea engelmannii–Abies lasiocarpa* forest, 33°57'30"N, 109°32'W, ca. 2750 m, on twigs of *Picea engelmannii*, on *Usnea* sp. (thallus), H. 36598 (GZU) and on *U.* cf. *fulvoreagens*, N. 34739 (with *Abrothallus usneae*) (ASU). Gila Co.: Gila N. F., upper end of Pine Canyon adjacent Coconino Co. border, mixed conifer and oak forest, 34°26'N, 111°24'W, ca. 2235 m, on *Usnea hirta* (thallus), N. 42005 (ASU). Pima Co.: along road to Mount Lemon, NE of Tucson, pine and fir forests with exposed rock outcrops, 32°25'N, 110°43'W, 2300 m, on *Usnea hirta* (thallus), B. D. Ryan 12533 (ASU). **Mexico, Baja California Sur.** Sierra de la Laguna, western slopes ESE above Todos Santos, *Quercus* forest in a steep N-facing ravine, 23°29'N, 109°59'W, 1500 m, on bark of old *Quercus*, on *Usnea* sp., H. 40317 (herb. Hafellner).

Bispora christiansenii D.Hawksw. (Hyphomycetes)

This species is known to occur on various lichens and lichenicolous fungi, including species of *Caloplaca*, *Candelariella*, *Clauzadea*, *Lecanora*, *Phacopsis* and *Phaeophyscia*. It is characterized by pale brown, (0–)1-septate conidia 5–8(–9) x 4–6 µm.
Distribution: Europe, Africa (Canary Islands), Asia (Russia, Papua New Guinea), North America* (Canada, U.S.A., Greenland). New to Arizona.
Sel. lit.: Hawksworth (1979); Alstrup & Hawksworth (1990), Alstrup & Cole (1998), Cole & Hawksworth (2001).

Specimen: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, along Hall Creek, *Picea–Abies* forest surrounding meadows, 33°58'N, 109°32'W, 2900 m, on *Punctelia subrudecta* (thallus) (in apothecia of *Phacopsis oxyspora* var. *defecta*), N. 34727 (ASU).

Buelliella inops (Triebel & Rambold) Hafellner comb. nov. (Ascomycetes: Dothideales)
Bas.: *Karschia inops* Triebel & Rambold in Santesson, Thunbergia 21: 7 (1994).

Because of the kind of opening of the ascocarps and the thin-walled, lately pigmented ascospores the species fits better in the genus *Buelliella*. This species was treated in detail by Triebel et al. (1991) and there reported from Arizona.
Distribution: Australia, North America (U.S.A., Mexico). New to Mexico.
Sel. lit.: Santesson (1994), Triebel et al. (1991).

Specimen: **Mexico. Chihuahua.** just N of Casa de Junos adjacent Río San Pedro, 30°41'55"N, 108°26'35"W, 1470 m, N-facing hillside in desert/oak woodland transition, on *Caloplaca* cf. *squamosa* (det. C.M. Wetmore), N. 36126 (ASU).

Cercidospora cecidiiformans Grube & Hafellner (Ascomycetes: Dothideales)

Two pyrenomycetes are known to cause the formation of galls on *Rhizocarpon* subgen.

Rhizocarpon. While those of *Endococcus macrosporus* (see below) are not very distinct and contain only few black perithecia, the galls of *Cercidospora cecidiiformans* are pillow-like and elevated with many hyaline perithecia.
Distribution: Europe; North America* (Greenland). New to North America (Greenland).
Sel. lit.: Hafellner (1993).

Specimen: **Greenland.** W-Grönland, Disko, Lyngmark, untere Hänge des Lyngmarksfjeld N Godhavn, 200 m, basalt, on *Rhizocarpon* subgen. *Rhizocarpon* spec. (thallus), Poelt & Ullrich (GZU).

Clypeococcum hypocenomycis D.Hawksw. (Ascomycetes: Dothideales)

This species is an easily detectable fungus as it discolors and blackens the squamules of its host. In the United States it was three times reported from Minnesota by Triebel (1989), Triebel et al. (1991) and Cole & Hawksworth (2001).
Distribution: Europe, North America (Canada, U.S.A.). New to Arizona.
Sel. lit.: Hawksworth (1980a); Triebel (1989), Triebel et al. (1991), Goward & Thor (1992), Alstrup & Cole (1998), Cole & Hawksworth (2001).

Specimen: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, between Phelp's cabin and the base of cliffs, 33°55'30"N, 109°30'30"W, ca. 2800 m, mixed conifer forest including large trees of *Pseudotsuga menziesii*, on *Hypocenomyce scalaris* (thallus), H. 36652 (GZU).

Cornutispora lichenicola D.Hawksw. & B.Sutton (Coelomycetes)

The species was first reported from the United States by Gierl & Kalb (1993), recently also by Cole & Hawksworth (2001).
Distribution: Europe, Africa (Canary Islands, Mauritius), Australasia (Australia), North America (U.S.A., Mexico). New to Mexico.
Sel. lit.: Hawksworth (1976); Gierl & Kalb (1993), Cole & Hawksworth (2001).

Specimen: **Mexico. Baja California Sur.** By the road (Hwy 19) between La Paz and Todos Santos, 9 km SSW of San Pedro, just N of El Carrizal turnoff, 23°50'N, 110°15'W, ca. 230 m, semidesert scrub on a plain, on bark of unknown shrub, on *Lecanora caesiorubella* (apothecial margins), H. 44765 & A. Hafellner (herb. Hafellner).

Corticifraga fuckelii (Rehm) D.Hawksw. & R.Sant. (Ascomycetes: Leotiales)

Corticifraga fuckelii has asci with a rather thick tholus and an ocular chamber present from an early stage of development, unthickened and scarcely pigmented paraphysal tips, and 1-septate spores. It was erroneously included in the North America checklist (Egan 1991) with a reference to Hawksworth & Santesson (1990) as these authors stated explicitly that they saw no specimens from North America. However, the species had been already mentioned from British Columbia by Noble et al. (1987).
Distribution: Europe, Africa (Canary Islands), Australasia (New Zealand), South America (Bolivia), North America (Canada, Mexico). New to Mexico.
Sel. lit.: Hawksworth & Santesson (1990); Noble et al. (1987), Goward & Ahti (1992), Goffinet (1994), Alstrup & Cole (1998), Santesson (2001).

Specimen: **Mexico. Chihuahua.** Sierra Madre Occidental, narrow valley ca. 28 km NW of Basaseachic, along the road (Hwy 16) to Yepáchic, 28°20'50"N, 108°15'45"W, 1720 m, riparian area with mixed forest (including *Alnus*) and scattered boulders, on boulders near stream on

Peltigera fibrillosa (thallus), H. 38834 (GZU), dupl. distributed in Santesson, Fungi Lichenicoli Exs. no 311.

Dactylospora athallina (Müll.Arg.) Hafellner (Ascomycetes: Dactylosporaceae, fam. incertae sedis)

The records of *Dactylospora saxatilis* by Tuckerman (1888) and Fink (1935) obviously refer to *D. athallina*, as the author mentioned *Baeomyces* as host genus and not *Pertusaria*. One of these specimens has been revised as *D. athallina* later on (Hafellner 1979). These species are easily separable by the red-brown epihymenium of *D. athallina* producing a purplish solution in K.
Distribution: Europe, North America (U.S.A.). New to Arizona.
Sel. lit.: Hafellner (1979); Tuckerman (1888, sub *Buellia saxatilis*), Keissler (1933), Fink (1935, sub *Buelliella saxatilis*).

Specimen: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, trail from Sheep's Crossing, *Picea engelmannii* forest in NE-exposition, 33°55'45"N, 109°33'W, ca. 2900 m, on earth beside the trail, on *Baeomyces rufus* (thallus), H. 36712 (herb. Hafellner).

Dactylospora attendenda (Nyl.) Arnold (Ascomycetes: Dactylosporaceae, fam. incertae sedis)

On the mainland the species was first recorded from Washington by Triebel (1989) on *Pilophorus acicularis*. Also in Canada, it was so far known only in the west. The identity of the earlier record from a Bering Strait island (Nylander 1866) is somewhat uncertain.
Distribution: Europe, Asia (Russia, Nepal, Japan), North America (Canada, U.S.A.).
Sel. lit.: Triebel (1989); Nylander (1866, sub *Lecidea parasitula*), Stizenberger (1876), Tuckerman (1888), Alstrup & Cole (1998).

Specimens: **Canada. Québec.** Manicouagan: Forêt Montmorency, SE of Réserve faunique de Laurentides, ca. 75 km NNE of Québec, region ca. 3.5 km E of the experimental station of the Université Laval, "Chute de la Rivière Noire" walk, SE of the Rivière Noire, wayside. 47°20'N, 71°06'W, ca. 700 m, on rotten tree trunk, on *Icmadophila ericetorum* (thallus), T. & Rambold 6132 (M). Ibid., on *Icmadophila ericetorum* (thallus) growing together with *Thelocarpon lichenicola* (separated), Rambold 6133 (M).

Dactylospora pleiosperma Triebel spec. nov. (Ascomycetes: Dactylosporaceae, fam. incertae sedis)

Fungus lichenicolus, in thallis apotheciisque lichenis Lecanora caesiorubella subsp. merrillii crescens. Apothecia sessilia vel substipitata, nigra, 0.1–0.15 mm in diametro, excipulo externe obscuro-fusco, interne incolorato, hypothecio hyalino; paraphyses apicibus incrassatis et crassis pigmentosis; asci 32–64-spori; ascosporae ellipsoideae, uniseptatae, fuscae, (4.5–)5–6.5(–7) × 2.5–3.5(–4) µm.

Typus: **U.S.A. California.** Santa Cruz Island, Sauers Canyon, lower edge of pine forest, on *Heteromeles arbutifolia*, on *Lecanora caesiorubella* Ach. subsp. *merrillii* Imshaug & Brodo (thallus and apothecia), Bratt 4517 (SBBG – holotype).

Icon.: Fig. 1 (ascospores)

Vegetative hyphae hyaline, c. 4 µm diam. Ascomata single to grouped on thallus and apothecia of the host lichen, apothecioid, erumpent, sessile to substipitate, 0.1–0.15

mm diam., round to irregular, often urceolate, disc plane to slightly concave, dark brown to black; margin distinct to thick, black, rough to striate; excipulum c. 20–35 µm thick, outer part dark brown, inner part hyaline, composed of more or less ellipsoid cells of c. 3–5 µm width; hypothecium hyaline, c. 30–40 µm tall, pseudoparenchymatic; hymenium hyaline, c. 60–70 µm tall, hymenial gel I+ bluish brown to reddish brown; paraphyses septate, branched and anastomosing, c. 1.5–2 µm wide, apical cells with thick dark brown caps, c. 2.5–4.5 µm wide; caps elongate; epihymenium dark brown, 8–10 µm tall; asci clavate, 58–64 × 13–16 µm, *Dactylospora*-type with extern I+ blue amyloid cap; outer ascus wall I+ brown to redbrown; ascospores ellipsoid, 1-septate, middle brown, c. 32–64 per ascus, (4.5–)5–6.5(–7) × 2.5–3.5(–4) µm; ascospore wall thin, smooth; the brown ascomatal pigments show no reaction using K; pycnidia not observed.

Host: *Lecanora caesiorubella* Ach. subsp. *merrillii* Imshaug & Brodo

Remarks: Some *Dactylospora*-species with plurisporous asci are already known: *Dactylospora hafellneriana* Sérusiaux (on *Santessonia*), *D. microspora* Etayo (on *Catinaria*), *D. pertusariicola* (Willey & Tuck.) Hafellner (on *Pertusaria*) and *D. polyspora* Triebel (on *Protoparmelia*) (Etayo 1991, Triebel 1989). Within this group of species *D. pleiosperma* is well characterized by its hyaline hypothecium, spore size, the lacking of a K-reaction of the pigments and the host lichen *Lecanora caesiorubella* subsp. *merrillii*.

Distribution: North America (U.S.A.: California).

Further specimens (all on *Lecanora caesiorubella* subsp. *merrillii*): **U.S.A. California.** Santa Barbara Co.: Santa Rosa Island, along road to East Point, isolated oak stand, 119°57'N, 33°57'W, ca. 170 m, N. 32878 (ASU); Santa Cruz Island, eastern pines areas, on *Quercus dumosa*, 290 m, Bratt 7435 (SBBG); Santa Cruz Island, slope above China Harbor, on branches, R. Gankin 27645.7 (SBBG).

Endococcus macrosporus (Arnold) Nyl. (Ascomycetes: Verrucariales)

Endococcus macrosporus was treated by Triebel (1989) as a synonym of *E. perpusillus* Nyl. using a wide species concept. Using a narrower species concept the taxon on *Schaereria* has to be named *E. perpusillus* and the morphologically similar *Endococcus* on *Rhizocarpon* has to be named *E. macrosporus.* Beside the occurrence on the thallus of yellow *Rhizocarpon* spp., where it induces the areolae to become more convex than healthy ones, *E. macrosporus* might have sometimes slightly larger ascospores with spore walls being apically somewhat darker and larger ascomata as *E. perpusillus* s. str. One specimen (N. 7569) cited by Triebel et al. (1991) under the name *E. perpusillus* actually belongs here. Furthermore it should be kept in mind that *Rhizocarpon* species can be infested by other closely related species (Triebel 1989, Sérusiaux et al. 1999).

Distribution: Europe, Africa (Morocco, Canary Islands), Asia (Turkey, Russia), Australasia (New Zealand), North America (U.S.A., Greenland). Newly recognized as a separate species for North America (U.S.A.: Arizona).

Sel. lit.: Arnold (1868), Triebel (1989, sub *E. perpusillus* p. p.); Alstrup & Hawksworth (1990, sub *E. stigma* p. p.), Triebel et al. (1991, sub *E. perpusillus* p. p.).

Specimen: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, along Hall Creek, 33°57'30"N, 109°32'W, ca. 2750 m, on volcanic conglomerate in a pasture surrounded by *Picea engelmannii*–

Abies lasiocarpa forest, on *Rhizocarpon geographicum* (thallus), H. 36590 (GZU).

Endococcus oreinae Hafellner spec. nov. (Ascomycetes: Verrucariales)

Species ad gregem Endococci perpusilli pertinet. Differt ab Endococco perpusillo ascosporis maioribus et ab Endococco macrosporo ascosporis minoribus et ascomatibus disperse in thallo hospitis vigentibus. Habitat supra thallum Dimelaenae oreinaesed infectio non cecidiogena.

Typus: **Mexico. Sonora.** By the road from Hermosillo to Sahuaripa, 85 km E of Highway 15, on boulders in shrubby upland Sonoran Desert vegetation, on *Dimelaena oreina* (Ach.) Norman (thallus), 21. II. 1987, T.H. Nash & J. Poelt (ASU–Holotypus, GZU–Isotypus).

Icon.: Fig. 2 (ascospores)

Infection not cecidiogenous. Vegetative hyphae indistinct. Ascomata c. 1–5 per areola, dispersed, sunken into the areolae of the host, only apical part visible under the the dissecting microscope, with apical ostiolum, c. 140–200 µm high and 140–200 µm in diam.; wall of ascoma in longitudinal section brown throughout, somewhat paler towards the base, laterally c. 20 µm in diam., composed of tangentially flattened cells, in the upper part darker brown, up to 40 µm thick and cells subsphaerical. Interascal filaments lacking in mature ascomata, crown of periphysoids persisting, periphysoids simple or branched, 7–15 µm long, c. 1.5 µm thick. Asci 8-spored, as typical for *Endococcus*, ascus wall thickened in about the upper third, 50–65 x 10–15 µm, periascal gel hemiamyloid (I+ orange, KI+ blue). Ascospores 1-septate, both cells more or less of equal shape and size, relatively late becoming brownish to pale brown, spore wall thin, somewhat constricted at the septum or not, without visible perispore in LM, 16–*17.9*–20 x 5–*5.9*–7 µm, length/width ratio c. 3.0. Anamorph not seen.

Host: *Dimelaena oreina* (Ach.) Norman

Etymology: oreinae – of [*Dimelaena*] *oreina*, because the species seems to be restricted to the *Dimelaena oreina* agg.

Remarks: Regarding the spore characters, the new species belongs to the *Endococcus perpusillus* group. It is distinguished from *E. macrosporus* (Arnold) Nyl. by (1) smaller ascospores, whose ends are not darker pigmented, (2) dispersed ascomata in areolae that do not become more convex by the infection, and (3) host selection (the type host of *E. macrosporus* is *Rhizocarpon geographicum*), from *E. perpusillus* Nyl. by larger ascomata, larger ascospores and host selection (the type host of *E. perpusillus* is *Schaereria fuscocinerea*), and from *E. pseudocarpus* Nyl. by somewhat different spore dimensions and shape as well as host selection (the type host of *E. pseudocarpus* is *Peltula euploca*) (type hosts as indicated by Triebel 1989).

While *Dimelaena* is famous for hosting several lichenicolous lichens (e.g. *Buellia imshaugii* Hafellner, *Caloplaca epithallina* Lynge, *Rhizocarpon renneri* Poelt), lichenicolous pyrenomycetes are much less common on this host genus. So far only three are known to grow on *Dimelaena,* all of which are rarely collected: the plurivorous *Muellerella pygmaea* (Körb.) D.Hawksw. var. *athallina* (Müll.Arg.) Triebel, the more specific *Endococcus buelliae* (C.W.Dodge) Matzer (Matzer et al. 1996) and *Polycoccum evae* Calatayud & Rico (Calatayud & Rico 1995). Within the host genus, *E. buelliae*, a species easily distinguished from *E. oreinae* by its much broader ascospores with thick spore walls provided with a perispore, is obviously restricted to the *Dimelaena radiata* group, while *Dimelaena oreina* is infested by a

clearly different species described above. The species was first mentioned from Arizona by Triebel et al. (1991, sub *E. perpusillus* p. p.).
Distribution: North America (U.S.A., Mexico)

Further specimens (all on *Dimelaena oreina*): **U.S.A. Arizona.** Apache Co.: 13 km N of Spingerville by the road (Hwy 180) to Saint Johns, about 4 km S of intersection with county road 4162, outcrops of lava flow in a pasture, 34°14'N, 109°20'30"W, ca. 1900 m, on volcanic rock exposed to NW, H. 36838 (herb. Hafellner). Coconino Co.: Grand Canyon National Park, slopes along Hermit Trail NW below Hermits Point, rocky slope with scattered trees of *Pinus edulis*, 36°03'30"N, 112°13'W, ca. 1900 m, on cliffs of siliceous sandstone, H. 36987 (GZU). Santa Cruz Co.: Coronado National Forest, Sycamore Canyon ca. 25 km W of Nogales, 31°25'N, 111°11'W, ca. 1200 m, siliceous rocks, on cliffs exposed to NW, H. 45543 & A. Hafellner (herb. Hafellner). **Mexico, Sonora.** Paso El Encino ca. 23 km ENE of Moctezuma, N-facing outcrops in a small ravine, 29°52'N, 109°28'W, ca. 1160 m, on quartzitic rock, H. 37634 & A. Hafellner (herb. Hafellner). 4–7 km E of Puente Huasabas, 29°55'30"N, 109°15–17'W, 900–1040 m, N. & J. Poelt (GZU). **Chihuahua.** Sierra Madre Occidental, mountain chains W of Nuevo Casas Grandes, hills ca. 15 km SW of Janos, cliffs in desert/oak woodland transition zone, 30°41'55"N, 108°26'35"W, ca. 1500 m, on NE-facing rhyolite cliffs, H. 37106 (herb. Hafellner). Sierra Madre Occidental, mountain chains W of Nuevo Casas Grandes, foothills SW of Janos, by the road to Hacienda Casa de Adobe, volcanic cliffs overlooking the valley, 30°40'25"N, 108°29'45"W, ca. 1600 m, on rock faces exposed to the NW, H. 37146 (herb. Hafellner).

Endococcus stigma (Körb.) Stizenb. s. str. (Ascomycetes: Verrucariales)

Endococcus stigma has been confused with *E. perpusillus* s. l., but is characterized by thick-walled, dark, ovoid to broadly ovoid (L:W $\leq$ 2.4) ascospores with one or both ends strongly attenuated, 12–16(–20) x (4–)6(–8) µm (Triebel 1989).
Distribution: Europe, North America* (U.S.A.). New to North America (U.S.A.: Arizona).
Sel. lit.: Körber (1865), Triebel (1989).

Specimens: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, Apache N. F., between Phelp's cabin and base of cliffs, ca. 2800 m, 33°55'30"N, 109°30'30"W, mixed conifer forest including large trees of *Pseudotsuga menziesii*, on boulders of volcanic conglomerate at the edge of the forest, on *Acarospora* subgen. *Phaeothallia* sp. (thallus), H. 36669 (GZU). Ibid., 33°55'N, 109°31'W, ca. 3000 m, on *Acarospora* subgen. *Phaeothallia* spec., Ryan & N. 27011 & 27104 (ASU).

Endococcus verrucosus Hafellner (Ascomycetes: Verrucariales)

This species is characterized by ascospores having thick, stratified, distinctly verrucose walls with a stronger mediane pigmentation, measuring 14–17 x 7–9 µm. It is restricted to *Aspicilia* species and was so far known from different European countries (Hafellner 1994).
Distribution: Europe, North America* (U.S.A.). New to North America (U.S.A.: Arizona).
Sel. lit.: Hafellner (1994).

Specimen: **U.S.A. Arizona.** Apache Co.: Apache N. F., Mt. Baldy Wilderness, along the trail to Baldy Peak from Sheep's Crossing, ca. 2900 m, 33°55'45"N, 109°33'W, *Picea engelmannii* forest in NE-exposition, on conglomerate boulders in the shade of the forest, on *Aspicilia* spec., H. 55499 (GZU).

Hawksworthiana peltigericola (D.Hawksw.) U.Braun (Hyphomycetes)

This species is characterized by conidia 15–25 x 5–7 µm, at least some of them being one-septate, and mono- to polyblastic conidiogenous cells. It forms gall-like convex swellings on *Peltigera* thalli similar to those caused by *Refractohilum peltigerae* (Keissl.) D. Hawksw.
Distribution: Europe, North America (Canada, Mexico, Greenland). New to Mexico.
Sel. lit.: Hawksworth (1980b), Braun (1995); Alstrup & Hawksworth (1990), Goward et al. (1994).

Specimens: **Mexico. Chihuahua.** Sierra Madre Occidental, narrow valley ca. 28 km NW of Basaseachic, along the road (Hwy 16) to Yepáchic, 28°20'50"N, 108°15'45"W, 1720 m, riparian area with mixed forest (including *Alnus*) and scattered boulders, on boulders near the stream, on *Peltigera fibrillosa* (thallus) together with *Lichenopeltella peltigericola*, H. 38826 (herb. Hafellner). Ibid., H. 46620 (GZU).

Karschia talcophila (Ach.) Körb. (Ascomycetes: Dothideales)

This widely distributed species is characterized by ascomata 0.3–0.6 mm diam., brown hypothecium, with the central part often somewhat darker, hymenium 60–90 µm, fissitunicate (4–)8-spored asci 50–65 x 12–15 µm, and dark brown, 1-septate ascospores, 11–*14.1*–17 x 6–*6.7*–8 µm, with the posterior cell distinctly narrower.
Distribution: Europe, Africa (Morocco), North America* (U.S.A., Mexico). New to North America (U.S.A.: Arizona, Mexico).
Sel. lit.: Hafellner (1979).

Specimens: **U.S.A. Arizona.** Coconino Co.: Coconino N. F.: W fork of Oak Creek, vicinity of W Buzzard Point, *Pinus ponderosa* forest in canyon, 35°01'15"N, 111°50'W, 1950 m, on *Diploschistes* sp., N. 35382 (det. Lumbsch) (ASU). Ibid., mixed conifer forest, on sandstone boulders, 35°02'N, 111°51'W, ca. 1900 m, on *Diploschistes* sp. (thallus), H. 36875 (herb. Hafellner). Greenlee Co.: Apache N. F., Mogollon Rim, Bear Wallow Wilderness, valley of S Fork of Bear Wallow Creek, mixed conifer forest in bottom of valley, 33°35'30"N, 109°26'30"W, ca. 2270 m, on boulders of volcanic rock, over mosses in shadow of forest, on *Diploschistes muscorum* (thallus), H. 36770 (GZU). **Mexico. Sonora.** Sierra Madre Occidental, by the road (Hwy 16) from Yécora to Tepoca, thorn forest with dominating *Acacia cymbispina* and low outcrops of sedimentary rock, 28°25'55"N, 109°13'50"W, ca. 700 m, on low rock outcrops, on *Diploschistes* sp. (thallus), H. 38902 (herb. Hafellner).

Lauderlindsaya borreri (Tul.) J.C.David & D.Hawksw. (Ascomycetes: Verrucariales)

The perithecioid ascomata from time to time are interpreted as belonging to the *Normandina pulchella* thallus, or as lichenicolous fungus on the former. The species has recently been reported from the United States (McCune 1997).
Distribution: Europe, Africa (Canary Islands), Asia (Papua New Guinea), Australasia (New Zealand), North America (U.S.A., Mexico). New to Mexico.
Sel. lit.: David & Hawksworth (1989), Aptroot (1991), Diederich & Serusiaux (1993); McCune (1997).

Specimen: **Mexico. Chihuahua.** Sierra Madre Occidental, mountain chain SSW of Ciudad Guerrero, W above the valley of Arroyo Ancho by the secondary dirt road to Heredia and Anexas, pine forest with scattered oaks on S-facing slope, 28°12'20"N, 107°38'55"W, ca. 2750 m, on bark of *Quercus*, on squamules of *Normandina pulchella*, H. 23722 (herb. Hafellner).

Lichenochora obscurioides (Linds.) Triebel & Rambold (Ascomycetes: Phyllachorales)

This species is characterized by crowded perithecia inducing the formation of gall-like swellings. Generally only the ostiola are visible and the area inbetween is slightly darkened. *Phaeophyscia rubropulchra* is a new host.
Distribution: Europe, North America (Canada, U.S.A.). New to the U.S.A. (Arizona, Michigan).
Sel. lit.: Hafellner (1989, sub *L. thallina*); Goward et al. (1994).

Specimens: **U.S.A. Arizona.** Greenlee Co.: Apache N. F.: Mogollon Rim: Bear Wallow Wilderness, valley of S Fork of Bear Wallow Creek, mixed conifer forest in bottom of valley, 33°35'30"N, 109°26'30"W, ca. 2270 m, on bark of *Quercus gambelii*, on *Phaeophyscia* sp. (thallus), H. 36756 (GZU). Santa Cruz Co.: Coronado N. F., Sycamore Canyon ca. 25 km W of Nogales, 31°25'N, 111°11'W, ca. 1200 m, siliceous rocks, on shady rock faces in the canyon, on *Phaeophyscia hispidula* (thallus), H. 45101 & A. Hafellner (GZU). **Michigan.** Mackinac Co.: Cut River Bridge on U.S. Highway 2, beside Lake Michigan, 46°03'N, 85°07'W, forest on steep slope, on *Phaeophyscia rubropulchra*, Poelt (GZU).

Lichenochora verrucicola (Wedd.) Nik.Hoffm. & Hafellner (Ascomycetes: Phyllachorales)

This species is unusual in the genus by its non septate ascospores. In the United States it was recently reported from South Dakota (Hoffmann & Hafellner 2000).
Distribution: Europe, North America (U.S.A.). New to Arizona.
Sel. lit.: Hoffmann & Hafellner (2000).

Specimen: **U.S.A. Arizona.** Coconino Co.: Grand Canyon National Park, slopes along Hermit Trail NW below Hermits Point, ca. 1900 m, 36°03'30"N, 112°13'W, rocky slope with scattered trees of *Pinus edulis*, on cliffs of siliceous sandstone, on *Aspicilia* spec., H. 55155 (herb. Hafellner).

Lichenoconium erodens M.S.Christ. & D.Hawksw. (Coelomycetes)

Lichenoconium erodens has small pycnidia (20–)30–50(–60) µm diam., conidiogenous cells (3.5)4–5(–6) x (2–)3–3.5(–4) µm, and conidia 2–3.5(–4) µm. Infections normally cause bleaching of large areas of the host thallus and may be mistaken as an effect of air pollution.
Distribution: Europe, North America (U.S.A.). New to Arizona.
Sel. lit.: Hawksworth (1977, 1981); Cole & Hawksworth (2001).

Specimen: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, along Hall Creek, spruce-fir forest surrounding meadows, 33°58'N, 109°32'W, 2900 m, on *Punctelia subrudecta*, N. 34727 (in apothecia of *Phacopsis*) (ASU).

Lichenoconium usneae (Anzi) D.Hawksw. (Coelomycetes)

This coelomycete is a frequent inhabitant of a number of lichens, preferably Parmeliaceae on which it is found both on the thallus and the apothecial discs. Previous North American gatherings originate mainly from the western part of the continent.
Distribution: Europe, Africa (Canary Islands), Asia (Papua New Guinea), Australasia

(New Zealand), Antarctica, North America (Canada, U.S.A., Greenland). New to Quebec and Washington.
Sel. lit.: Hawksworth (1977, 1981); Noble et al. (1987), Alstrup & Hawksworth (1990), Alstrup & Cole (1998), Cole & Hawksworth (2001).

Specimens: **Canada. Québec.** Gaspésie: Parc National Forillon, 5 km ENE of Gaspé, "Penouille" peninsula, ca. 1 km SW of parking area, heath 200 m behind SE beach, 48°51'18"N, 64°25'08"W, on twigs of *Prunus pensylvanica*, on *Melanelia septentrionalis* (apothecia) growing together with *Cornutispora ciliata*, Rambold 6120 (M). **U.S.A. Washington.** Kittitas Co.: near Rimrock Lake, 8 km W of Rimrock Retreat, on dead branches of *Pinus ponderosa*, on *Hypogymnia imshaugii* (apothecia), Culberson & Ornduff (GZU).

Lichenodiplis lecanorae (Vouaux) Dyko & D.Hawksw. (Coelomycetes)

Lichenodiplis lecanorae was discussed by Triebel et al. (1991) who reported it first from continental North America. It is characterized by conidia of 4–7.5 x 2–3.2 µm and a scar diameter of 1.5–2 µm (Berger & Diederich 1996), but supposed to be a species aggregate. The specimen on *Caloplaca cerina* has scars of similar size as *L. lecanorae* s. str. but conidia of 8–10.5 x 4–4.5 µm. It is preliminarily placed here.
Distribution: Europe, Africa (Marocco, Madeira, Canary Islands), Asia (Cyprus), South America (Argentina), North America (U.S.A., Greenland). New to Mexico.
Sel. lit.: Berger & Diederich (1996), Hawksworth & Dyko (1979), Hawksworth (1981); Alstrup & Hawksworth (1990), Triebel et al. (1991), Cole & Hawksworth (2001).

Specimens: **Mexico. Sonora.** Sierra Madre Occidental, mountain ridge W of Yécora by the road (Hwy 16) to San Nicolás, N-facing slope with *Pinus–Quercus* forest and large rhyolite outcrops, 28°22'45"N, 109°02'20"W, ca. 1900 m, on apothecia of *Lecanora caesiorubella* on bark of *Quercus oblongifolia*, H. 39334 (GZU). **Arizona.** Coconino Co.: Kaibab N. F., adjacent secondary road to Fire Point and at boundary to Grand Canyon N. P., *Pinus ponderosa* forest, 36°22'N, 112°20'30"W, 2240 m, on *Caloplaca cerina* (conf. C.M. Wetmore), N. 34637, (ASU).

Lichenopeltella peltigericola (D.Hawksw.) R.Sant. (Ascomycetes: Dothideales)

This species is characterized by thyriothecia 50–70 µm; ostiole with 3–6 red-brown stiff diverging setae; asci 4-spored; ascospores 1-septate, (13.5–)15–21 x (3–)4–5 µm. It grows preferably on the lower side of old *Peltigera* thalli, especially on the veins. The second known *Lichenopeltella* growing on *Peltigera*, *L. santessonii*, is distinguished by its converging setae.
Distribution: Europe, Africa (Madeira), Asia (New Guinea), North America (Canada, U.S.A., Mexico). New to Mexico.
Sel. lit.: Hawksworth (1983), Spooner & Kirk (1990); Alstrup & Cole (1998), Cole & Hawksworth (2001).

Specimen: **Mexico. Chihuahua.** Sierra Madre Occidental, narrow valley ca. 28 km NW of Basaseachic, along the road (Hwy 16) to Yepáchic, riparian area with mixed forest (including *Alnus*) and scattered boulders, 28°20'50"N, 108°15'45"W, 1720 m, on boulders near the stream, on *Peltigera fibrillosa* (thallus), together with *Hawksworthiana peltigericola*, H. 38834 (herb. Hafellner, filed under *Hawksworthiana peltigericola*).

Lichenostigma elongata Nav.-Ros. & Hafellner (Ascomycetes: Arthoniales)

Lichenostigma elongata occurs on species of *Aspicilia* and *Lobothallia*, and is

characterized by elongate pseudothecia, connected with complex superficial hyphal strands, and ascospores (9–)10–13 x 6–8.5 µm large. It was first reported from continental North America (Arizona, Colorado) by Navarro-Rosinés & Hafellner (1996).
Distribution: Europe, Africa (Tunisia, Canary Islands), Asia (Cyprus, Jordania, Mongolia), Australasia (Australia), North America (U.S.A., Mexico). New to Mexico.
Sel. lit.: Navarro-Rosinés & Hafellner (1996).

Specimens: **U.S.A. Arizona.** Apache Co.: Apache N. F.: Mt. Baldy Wilderness, ridge NW above the valley of the E fork of the Little Colorado River, ca. 2950 m, 33°55'30"N, 109°31'W, large cliffs of volcanic conglomerate, on rock faces exposed to SE, on *Lobothallia* sp., H. 55786 (GZU). NE of Big Lake, by the main forest service road (113), open rocky area with scattered trees, on boulders of volcanic rocks exposed to the W, 33°53'40"N, 109°24'30"W, ca. 2620 m, on *Aspicilia* sp. (apothecia), H. 36628 (GZU). along route 666, 23.5 km N of St. Johns, shrubland with scattered junipers, 34°49'N, 109°14'15"W, ca. 1860 m, on basalt, N. 40277 (ASU). **California.** San Diego Co.: Agua Tibia Wilderness, Magee Palomar trail at Crossley Saddle, chaparral with oaks, ca. 1050 m, on granite, B.D. Ryan 25952 (ASU). Monterey Co.: Hastings Ecological Preserve, *Quercus douglasii* woodland, 36°22'30N, 121°34'15W, 550 m, on *Aspicilia calcarea* s. l., Ryan 27051 (ASU). **Mexico. Baja California Sur.** Peninsula Vizcaíno, along road to Bahía Tortugas, 152 km W of MEX 1, Pleistocene alluvial deposits, 27°38'N, 114°32'W, 150 m, on *Aspicilia*, N. 29630 (ASU).

Lichenostigma maureri Hafellner (Ascomycetes: Arthoniales)

This species occurs on thalli of foliose or fruticose lichens (e.g. *Usnea*, *Pseudevernia*, *Alectoria*, *Letharia*). It is characterized by black immarginate ascomata, being 70–120 µm diam. and 30–40 µm high and 1-septate ascospores, that become soon moderate to dark brown and being 9–*10.7*–12 x (4–)4.5–*5.4*–6 µm large. In the United States it was previously reported from Colorado (Fink 1935, sub *Buelliella usneae*; compare Esslinger & Egan 1995: 539).
Distribution: Europe, Africa (Madeira, Canary Islands), Asia (Turkey, Georgia), Asia (New Guinea), South America (Argentina, Peru), North America (U.S.A.). New to Arizona.
Sel. lit.: Hafellner (1982); Fink (1935), Esslinger & Egan (1995).

Specimens: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, Trail from Phelp's Cabin, 33°56'N, 109°30'W, 2900 m, on *Usnea hirta* (det. M. Herrera), N. 27172 (ASU). Mt. Baldy Wilderness, along Hall Creek, 2900 m, 33°58'N, 109°32'W, *Picea–Abies* forest surrounding meadows, on *Usnea* cf. *fulvoreagens*, N. 34739 (ASU). Greenlee Co.: Apache N. F., Bear Wallow Wilderness, along trail 63, mixed conifer forest, 33°36'0"N, 109°25'0"W, ca. 2640 m, on *Usnea* spec., N. 41861 (ASU).

Lichenostigma rugosa Thor (Ascomycetes: Arthoniales)

The taxon is restricted to *Diploschistes* species, on which it develops its somewhat irregular ascomata. It has been reported from Utah by Thor (1985) and from Arizona by Triebel et al. (1991).
Distribution: Europe, Africa, (Libya, Canary Islands), Asia (Iran, Saudi Arabia), Australasia (Australia), North America (Canada, U.S.A., Mexico). New to Mexico.
Sel. lit.: Thor (1985); Triebel et al. (1991), Alstrup & Cole (1998).

Specimen: **Mexico. Sinaloa.** ca. 30 km NW of Los Mochis, about 3 km NNE of Higuera de

Zaragoza, W end of hill chain NW of Ahome, semidesert scrub with volcanic outcrops on NW-facing hillside, on small boulders, 26°01'N, 109°16'W, ca. 50 m, H. 40202 & A. Hafellner (herb. Hafellner).

Muellerella lichenicola (Sommerf. : Fr.) D.Hawksw. (Ascomycetes: Verrucariales)

The specimens fit well in the species concept of *M. lichenicola* as given in Triebel (1989).

Distribution: Worldwide in extra-tropical regions, also in North America (U.S.A., Greenland). New to Arizona and California.

Sel. lit.: Triebel (1989); Alstrup & Hawksworth (1990), Triebel et al. (1991).

Specimens: **U.S.A. California.** Santa Barbara Co.: Santa Rosa Island, S-facing slope just W of Bee Canyon, 120°12'W, 33°58'15"N, 170 m, soft chaparral, on *Pertusaria xanthodes* (mostly in apothecia), N. 32710 (ASU). **Arizona.** Gila Co.: 1 km S of Flowing Springs, cliffs above the East Verde River, 34°18'N, 111°12'W, 1400 m, on *Caloplaca citrina*, N. 39316 (ASU).

Nectriopsis lecanodes (Ces.) Diederich & Schroers (Ascomycetes: Hypocreales)

This species is characterized by sessile, pale yellow to orange perithecia with ascospores 9–12 x 3–4 µm (Booth 1959). It causes extensive damage to species of *Lobaria*, *Nephroma*, *Peltigera* and *Pseudocyphellaria*.

Distribution: Europe, Africa (Madeira, Canary Islands), Asia (New Guinea), North America (Canada, U.S.A., Mexico). New to Mexico.

Sel. lit.: Booth (1959); Esslinger & Egan (1995), Alstrup & Cole (1998), Santesson (2001).

Specimens: **Mexico. Chihuahua.** Sierra Madre Occidental, narrow valley ca. 28 km NW of Basaseachic, along the road (Hwy 16) to Yepáchic, 28°20'50"N, 108°15'45"W, 1720 m, riparian area with mixed forest (including *Alnus*) and scattered boulders, on *Peltigera austroamericana* (thallus), H. 38830 (GZU), dupl. distributed in Santesson, fungi lichenicoli exs. no 322. Ibid., H. 46622 (GZU). **Baja California Sur.** Sierra de la Laguna, western slopes ESE above Todos Santos, 1500 m, 23°29'N/109°59'W; *Quercus* forest in a steep N-facing ravine, on moist earth, H. 40291 (GZU), dupl. distributed in Santesson, Fungi Lichenicoli Exs. no 321.

Opegrapha glaucomaria (Nyl.) Källsten ex Hafellner (Ascomycetes: Arthoniales)

Opegrapha glaucomaria is characterized by its epruinose ascomata with exposed discs, pale ascospores, and occurrence on the *Lecanora rupicola* group. In Europe it has also been reported growing on *Protoparmelia badia*.

Distribution: Europe, Africa (Canary Islands), Asia (Russia), North America (U.S.A., Greenland). New to Arizona.

Sel.lit.: Nylander (1853), Hafellner (1994); Stizenberger (1876), Tuckerman (1888), Fink (1935).

Specimen: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, between Phelp's cabin and base of cliffs, mixed conifer forest including large trees of *Pseudotsuga menziesii*, 33°55'30"N, 109°30'30"W, ca. 2800 m, on boulders of volcanic conglomerate at the edge of forest, on *Lecanora rupicola* (thallus), H. 36639 (GZU).

Opegrapha pertusariae (Vouaux) Hafellner (Ascomycetes: Arthoniales)

Etayo & Diederich (1998) regarded *O. anomea* Nyl. and *O. pertusariae* as being "provisionally" synonymous, regarding the differences in ascospore pigmentation of minor importance. As the characters of the specimen cited below fit perfectly the description of *O. pertusariae*, we prefer to use this name.
Distribution: Africa (Canary Islands), North America* (U.S.A.). New to North America (U.S.A.: California).
Sel. lit.: Vouaux (1913), Hafellner (1994), Etayo & Diederich (1998).

Specimen: **U.S.A. California.** Los Angeles Co.: Santa Catalina Island, 0.8 km NW of Catalina air field at junction of road to Avalon and secondary road to coast, 33°24'15"N, 118°24'45"W on *Pertusaria* cf. *amara*, N. 32086 (ASU).

Opegrapha physciaria (Nyl.) D.Hawksw. & Coppins (Ascomycetes: Arthoniales)

This species is characterized by its epruinose ascomata with wide discs, and occurrence on thalli of species of the *Xanthoria parietina* group. As the hitherto only record from North America (California) is from *Caloplaca rosei* (Cole & Hawksworth 2001), this specimen would need to be checked again.
Distribution: Europe, Africa (Marocco, Canary Islands), Asia (Israel), Asia (New Guinea), North America (U.S.A., Mexico). New to Mexico.
Sel. lit.: Atienza (1992), Pentecost & James (1992); Cole & Hawksworth (2001).

Specimens: **Mexico. Baja California.** Cerro Kenton and adjacent area, W of Bahía de San Quintín, 38°28'N, 116°00'W, on *Xanthoria* sp., N. & Poelt (GZU). Pacific Ocean beach front area W of Cerro Kenton and Bahía de San Quintín, 30°28'N, 116°03'W, on shrubs, on *Xanthoria* sp., N. & Poelt (GZU). Peninsula SW of San Quintín, surroundings of Cerro Kenton, small hills SW of the volcano, 30°28'N, 116°W, ca. 50 m, desert scrub, on small shrubs, on *Xanthoria* sp., H. 41099 & A. Hafellner (herb. Hafellner). **Baja California Sur.** coastal plain about 40 km S of Ciudad Constitution by the road (Hwy 1) to La Paz, at turnoff to Puerto Cancun, 24°43'N, 111°33'W, ca. 30 m, desert scrub, on branches of a small tree, on *Xanthoria parietina*, H. 46494 (GZU).

Opegrapha pulvinata Rehm (Ascomycetes: Arthoniales)

Opegrapha pulvinata has epruinose ascomata, soon dark brown ascospores, and is occurring on saxicolous members of the Verrucariales. It has been previously reported in North America from *Staurothele* spp., but all specimens cited here are on thalli of *Dermatocarpon*. Duplicates of the Chihuahuan specimen have been distributed in Santesson, Fungi Lichenicoli Exs. no. 273 (Santesson 1998). It would be worth to check if *Homostegia dermatocarpae* (Alstrup & Cole 1998) is a later synonym, because the authors stated that the hymenial gel of that species reacts I+ blue. This is in fact the case in *O. pulvinata*, but would be unusual for a *Homostegia* species.
Distribution: Europe, Africa (Marocco), Asia (Afghanistan, specimen in GZU), North America (U.S.A., Mexico). New for Arizona.
Sel. lit.: Rehm (1891), Hafellner (1994); Bouly de Lesdain (1932 – sub *Leciographa centrifuga*), Fink (1935), Santesson (1998).

Specimens (on *Dermatocarpon* spec. indet. if not otherwise stated): **U.S.A. Arizona.** Apache Co.: Apache N. F.: valley of Black River, surroundings of the bridge of road FR 25, remnants of oak forest and cliffs above the riverbank, 33°42'20"N, 109°27'W, ca. 2100 m, on cliffs exposed to the S, H. 36844 (GZU). Coconino Co.: Grand Canyon N. P., N slopes along Grand View Trail below Grand View Point, rocky slope with scattered trees of *Pinus edulis*, 36°00'N, 111°59'W, 2000 m, on cliffs of calcareous sandstone, on *D. miniatum* coll. (thallus), H. 36900 (GZU). **Mexico. Chihuahua.** Sierra Madre Occidental, along E bank of Río Sirupa adjacent a secondary dirt road, ca. 32 km W of Ciudad Madera, pasture with scattered *Quercus* (open oak forest), siliceous rocks, 29°11'N, 108°19'25"W, 1340–1350 m, on low cliffs exposed to the N, H. 37658 (GZU). Ibid., on *D. moulinsii* (thallus), N. 36246 (ASU). **Sonora.** 5 km W of Moctezuma, on E side of the Sierra la Cienguita, NE-facing hillside above the creek, 29°46'N, 109°43'W, 790 m, open *Quercus* forest, on small exposed cliffs of siliceous sandstone, H. 37638 & A. Hafellner (herb. Hafellner). 33 km SW of Moctezuma, S of the road to Hermosillo, gentle N-facing slope above streamside with *Populus* and open *Quercus* forest and low N-facing cliffs of basaltic rock, 29°38'N, 109°56'W, 1000 m [950 according to H.], on low NE-facing cliffs of basaltic rock, H. 37658 & A. Hafellner (GZU). 27.5 km ENE of Ures, 29°31'N, 110°56'W, 620 m, open shrubland on N-facing slope, on N-facing granitic outcrops, H. 37666 & A. Hafellner (GZU, herb. Hafellner). 7 km W of Huásabas (28 km E of Moctezuma), 29°55'N, 109°23'W, 760 m, small cliffs of volcanic rock in open shrubland, on rock faces exposed to the N, H. 37620 & A. Hafellner (herb. Hafellner).

Paranectria oropensis (Ces.) D.Hawksw. & Piroz. (Ascomycetes: Hypocreales)

This species is characterized by 8-spored asci and ascospores (22–)25–32(–36) x (9)11–14(–15) µm, with 5–8 transverse and 1–2 longitudinal septa. Recently a further subspecies, *Paranectria oropensis* subsp. *parviseptata*, has been described (Cole & Hawksworth 2001) which is also reported from the United States.
Distribution: Europe, North America* (Mexico). New to Mexico.
Sel. lit.: Samuels (1976 – sub *Ciliomyces oropensis*).

Specimen: **Mexico. Chihuahua.** Sierra Madre Occidental, narrow valley ca. 28 km NW of Basaseachic, along the road (Hwy 16) to Yepáchic, riparian area with mixed forest (including *Alnus*) and scattered boulders, 28°20'50"N, 108°15'45"W, 1720 m, on bark of *Alnus oblongifolia*, on *Phaeophyscia* sp. (thallus), H. 38848 (herb. Hafellner).

Phacopsis oxyspora (Tul.) Triebel & Rambold var. ***fusca*** Triebel & Rambold (Ascomycetes: Lecanorales)

Triebel et al. (1991, 1995) discussed this species and presented a key to the varieties in the 1995 article. *Hypotrachyna meridensis* is a new host for this taxon.
Distribution: Europe, Africa (Canary Islands, Cape Verde Islands), Australia, North America (U.S.A., Mexico). New to Arizona.
Sel. lit.: Triebel et al. (1995).

Specimens: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, trail from Phelp's Cabin, adjacent cliffs, mixed conifer forest including large *Pseudotsuga menziesii*, 33°55'30"N, 109°30'30"W, 2900 m, on *Hypotrachyna pulvinata*, N. 34911 (ASU). **Mexico. Chihuahua.** Small secondary valley within Barranca del Cobre, oak–pine–cypress forest, 27°26'20"N, 107°29'20"W, 1800 m, on *Hypotrachyna meridensis*, N. 36932 (ASU).

Phaeopyxis punctum (A.Massal.) Rambold, Triebel & Coppins (Ascomycetes: Leotiales)

Phaeopyxis punctum has I+ pale bluish ascus wall and ascospores that are (7–)8.5–10.5(–12) x 2.5–3.5(–4) µm. It occurs on *Cladonia* spp., occasionally inducing slight

gall-like deformations on the infested squamules.
Distribution: Europe, Africa (Madeira), Australasia (Campbell Island), North America (Canada, U.S.A.). New to Arizona.
Sel. lit.: Rambold & Triebel (1990); Arnold (1887, 1888, 1899), Fink (1935), Alstrup & Cole (1998).

Specimens: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, along Hall Creek, *Picea engelmannii–Abies lasiocarpa* forest, 33°57'30"N, 109°32'W, ca. 2750 m, on wood, on *Cladonia* sp. (thallus), H. 36583 (GZU). Greenlee Co.: Apache N. F.: Mogollon Rim: Bear Wallow Wilderness, valley of S Fork of Bear Wallow Creek, mixed conifer forest in bottom of valley, on 33°35'30"N, 109°26'30"W, ca. 2270 m, bark of *Abies lasiocarpa*, on *Cladonia* sp. (thallus), H. 36761 (GZU).

Phaeosporobolus usneae D.Hawksw. & Hafellner (Coelomycetes)

The genus *Phaeosporobolus* D.Hawksw. & Hafellner is characterized by conidiomata that open with irregular apical clefts and the formation of multicelled conidia looking similar to the spore balls of *Urocystis*. So far, two species have been described differing mainly in size and number of cells of their conidia. The ellipsoid conidia of *P. usneae* are about 15–20 µm in diam., composed of about a dozen of globose cells. The species inhabits a number of macrolichens, including species of *Bryoria*, *Evernia*, *Flavoparmelia*, *Letharia*, *Lethariella*, *Parmeliopsis*, *Pseudevernia*, *Ramalina*, and *Usnea*.
Distribution: Europe, Africa (Canary Islands), Asia (Russia), Australia (Capital Territory), Antarctica, South America (Argentina), North America (Canada, U.S.A., Greenland). New to Arizona.
Sel. lit.: Filson (1996), Hawksworth & Hafellner (1986); Alstrup & Hawksworth (1990), Alstrup & Cole (1998), Cole & Hawksworth (2001).

Specimens: **Canada, Ontario.** Near Norembega, 12 km SE of Cochrane, in *Picea mariana* in black spruce bog, ca. 48°55'N , 80°45'W, on *Evernia mesomorpha* (thallus), Wetmore (herb. Hafellner no. 41097). **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, trail from Phelp's Creek, 33°55'30"N, 109°31'W, 3000 m, on *Usnea hirta* (det. N.), Ryan & N. 26893 (with *Biatoropsis usnearum*) (ASU). Mt. Baldy Wilderness, along Hall Creek, *Picea engelmannii–Abies lasiocarpa* forest, 33°57'30"N, 109°32'W, ca. 2750 m, on twigs of *Picea engelmannii*, on *Usnea* sp., H. 36603 (herb. Hafellner), 40014 (GZU).

Phoma lobariae Diederich & Etayo (Coelomycetes)

The dispersed conidiomata of this species are found on older parts of *Lobaria* thalli. The conidia are subglobose truncate and c. 3–4 x 3 µm in diam. *Phoma lobariae* was so far only known from France and Spain.
Distribution: Europe, North America* (Canada). New to North America (Canada).
Sel. lit.: Etayo & Diederich (1995).

Specimen: **Canada. Québec.** Gaspésie: ca. 15 km E of Gaspé, Parc National Forillon, ca. 4 km NE of the village D'Aiguillon, "La Chute" walk, deciduous woods, beside walking trail above water fall, 48°50'35"N, 64°15'56"W, 100 m, on bark of *Acer saccharum*, on *Lobaria pulmonaria* (thallus), growing together with *Dactylospora lobariella* (Nyl.) Hafellner and *Plectocarpon lichenum*,T. & Rambold 6116 (M).

Phoma physciicola Keissl. (Coelomycetes)

The species is separated from other lichenicolous *Phoma* species by the broadly ellipsoid shape of the conidia, about 4–6 x 2.5–4 µm in diam. In the cited specimen the conidiomata are formed in the hymenia of the host which are destroyed by the infection, but in Europe it was also found growing on the thallus. In Canada, it was previously known only from British Columbia.
Distribution: Europe, North America (Canada).
Sel. lit.: Hawksworth (1981); Alstrup & Cole (1998).

Specimen: **Canada. Québec.** Bas-Saint-Laurent: ca. 25 km SW of Rimouski, NE of St. Fabien, Parc du Bic, E of Montagne à Michaud Mtn, beside walking trail near the bay "Anse à Wilson". 46°21'38"N, 68°47'57"W, ca. 20 m, on bark of tree, on *Physcia aipolia* (apothecia), Rambold 6113 (M).

Plectocarpon lichenum (Sommerf.) D.Hawksw. (Ascomycetes: Arthoniales)

The very conspicuous ascomata of this species produced in distinct galls are sometimes mistaken as apothecia of the infested *Lobaria*, but they differ markedly in colour. According to Diederich & Etayo (1994), records from other hosts than *Lobaria pulmonaria* should be treated as dubious. In Canada, it was previously known only from British Columbia.
Distribution: Europe, Africa (South Africa, Marocco, Canary Islands), Australasia (New Zealand), North America (U.S.A., Canada).
Sel. lit.: Diederich & Etayo (1994); Fink (1935), Noble et al. (1987), Thomson & Ahti (1994), Alstrup & Cole (1998).

Specimen: **Canada. Québec.** Gaspésie: ca. 15 km E of Gaspé, Parc National Forillon, ca. 4 km NE of the village D'Aiguillon, "La Chute" walk, deciduous woods, beside walking trail above water fall. 48°50'35"N, 64°15'56"W, 100 m, on bark of *Acer saccharum*, on *Lobaria pulmonaria* (thallus) growing together with *Dactylospora lobariella* and *Phoma lobariae*, T. & Rambold 6117 (M).

Plectocarpon nashii Hafellner spec. nov. (Ascomycetes: Arthoniales)

Ascomata conglomerata ex thallis hospitis erumpentia, rotundata ad deformata, discis primum obtectis demum expansis, nigra sed superficialiter ferrugineo pruinosa. Ascosporae triseptatae. A speciebus aliis generis Plectocarpon praecipue in apotheciis pigmento ferrugineo crystallino obtectis differt. In thallis lichenis Niebla robusta vigens.

Typus: **U.S.A. California.** Santa Barbara Co.: W end of West Anacapa Island, above Rat Rock, 34°00'50"N, 119°26'40"W, 60 m, on acidic rock, on *Niebla robusta* (R.Howe) Rundel & Bowler (thallus), 9. XI. 1995, T.H. Nash III 37021a (ASU–holotype, GZU–isotype).

Icon.: Fig. 3 (ascospores)

Infection without any symptoms besides the breakthrough of the ascomata. Vegetative hyphae below the ascomata not discernable in LM from hyphae of the host but hemiamyloid hyphae observed outside the exciple of young ascomata in the cortical plectenchyma of the host; living algae of the host present immediatelly below the ascomata. Ascomata breaking through the cortex of the host, slightly sunken at first but then somewhat elevated, up to 2.5 mm in diam., roundish, black but partly covered by a rusty brown pruina, developing irregular cracks and fissures in the layer above the hymenium which later breaks into separate parts; discs finally widely exposed, irregular, umbilicate or roundish, entirely covered by a rusty brown pruina, at the edges often with remnants of the layer formerly obscuring the disc; exciple in longitudinal section dark brown, interior part K+ blue-green, upper part K+ purple; hypothecium brown, hymenium brownish, c. 100 µm high, often separated into parts by sterile tissue, hymenial gel KI+ blue; crystals overlaying the hymenium golden in LM, reacting in K, giving a purple solution, intensity of colour slowly fading. Paraphysoids with many branches and anastomoses, c. 2.5–3 µm thick, all along but especially towards the upper ends surrounded by many small brownish granules, ends not markedly thicker. Asci arthonialean, broadly cylindrical, 6- or 8-spored, 80–90 x 20–25 µm; endoascus with hemiamyloid tube structure in the apex. Ascospores 3-septate, hyaline, slightly clavate or not, 19–*22.3*–25 x 6–*7.2*–8 µm [measurements without perispore], length/width ratio c. 3.1; with c. 1 µm thick hyaline perispore, but perispore shrinking with age and becoming brownish and slightly warty, giving the spores a brownish appearance.

Pycnidia incidentally found within the hymenia but separated by plectenchyma. Pycnidial wall with comparable texture as apothecial exciple. Conidiophores of type II (acc. to Vobis 1980). Conidia dimorphic in the same conidial cavity. Type 1 (microconidia) bacilliform, attenuated at lower end, non septate, c. 5–6 x 1–1.5 µm. Type 2 (macroconidia) bacilliform to slightly clavate, 1-septate, c. (12–)15–17 x 4–5 µm.

Host: *Niebla robusta* (R.Howe) Rundel & Bowler

Etymology: The species is dedicated to Thomas H. Nash III, the mentor and organiser of the Sonoran desert lichen flora project.

Remarks: The new species is distinguished from other *Plectocarpon* species by its finally widely exposed discs obscured by an orange pruina reacting K+ purple. Similar pigments are known from some lichenized arthonialean species, e.g. *Opegrapha ochrocheila* Nyl. and *O. ochrocincta* Werner, both with typical lirellate ascomata (Torrente & Egea 1989). Mature ascomata of *P. nashii* may remind one of *Lecanactis* coll., but early stages of ascoma development show that the species is best placed in *Plectocarpon*.

The species certainly does not belong to the core group of *Plectocarpon*. But as shown by Diederich & Etayo (1994), ascoma characters are rather plastic in the genus.

Distribution: U.S.A.: California (so far known only from the type locality).

Polycoccum clauzadei Nav.-Ros. & Cl.Roux (Ascomycetes: Dothideales)

The species has recently been described from southern France, where it was found growing on *Xanthoria elegans*. As the closely related *P. pulvinatum* it is gall-inducing. It can be distinguished from that species beside some other minor differences mainly by the ascospores which are obovate, measuring about 15–19 x 7–9 µm in *P. clauzadei*.

Distribution: Europe, North America* (U.S.A.). New to North America (U.S.A.: Nebraska).

Sel. lit.: Navarro-Rosinés & Roux (1998).

Specimen: **U.S.A. Nebraska.** Scotts Bluff Co.: Scotts Bluff National Monument, on northwest spur ridge from parking lot on North Bluff, along ridgetop on calcareous rocks, 41°50'19"N, 103°42'10"W, 1371 m, on *Caloplaca trachyphylla* (thallus), Wetmore 77575a, (separated from Wetmore, Telosch. Exs. No. 10) (GZU).

Polycoccum evae Calatayud & V.J.Rico (Ascomycetes: Dothideales)

This species is characterized by its halonate spores and seems to be restricted to the *Dimelaena oreina* group. Other than *P. pulvinatum* which is found on other Physciaceae (see below), it does not produce galls. It was so far known only from Spain.
Distribution: Europe, North America* (Mexico). New to North America (Mexico).
Sel. lit.: Calatayud & Rico (1995).

Specimen: **Mexico. Chihuahua.** Sierra Madre Occidental, mountain ridges W of Nuevo Casas Grandes, foothills SW of Janos, hills NE above water reservoir, scattered volcanic rocks in a pasture, 30°39'10"N, 108°27'45"W, ca. 1620 m, on N-facing cliffs on the hilltop, on *Dimelaena oreina* (thallus), H. 37121 (herb. Hafellner).

Polycoccum kerneri J.Steiner (Ascomycetes: Dothideales)

This species was hitherto known only occurring on host lichens of the *Lecidea fuscoatra*-group. *Lecidea tessellata* Flörke s. l. is a new host lichen.
Distribution: Europe, Africa (Canary Islands), North America* (U.S.A.). New to North America (U.S.A.: Arizona).
Sel. lit.: Hawksworth (1994), Hafellner (1996a).

Specimens: **U.S.A. Arizona.** Coconino Co./Gila Co.: (boundary): edge of Mogollon Rim, along AZ 260, 34°18'N, 110°54'W, 2310 m, S-exposed cliffs and boulders in open *Pinus ponderosa* forest, on *Lecidea tessellata* s. l. (det. Hertel), H. Hertel 40235 (M). Coconino Co.: Mogollon Rim, immediately W of where route 260 crosses the rim, pine forest, 34°18'N, 110°55'W, ca. 2300 m, on sandstone, on *Lecidea tessellata* s. l. , T.H. Nash 29560 (ASU).

Polycoccum opulentum (Th.Fr. & Almq.) Arnold (Ascomycetes: Dothideales)

This species is characterized by its rather large, halonate ascospores (mostly 22–27 x 10–15 µm) and its occurrence on endolithic calcicolous species of Verrucariaceae.
Distribution: Europe, Africa (Morocco), North America* (U.S.A.). New to North America (U.S.A.: Arizona).
Sel. lit.: Navarro-Rosinés & Roux (1990).

Specimen: **U.S.A. Arizona.** Yavapai Co.: dirt road 0.5 km NE of McGuireville, 3.2 km NE of Montezuma Castle National Monument, 34°38'N, 111°48'W, 1130 m, on *Verrucaria calciseda* and *Verrucaria obductilis* over calciferous rocks (60° N), Ryan 15221, det. Navarro-Rosinés (ASU, filed under *V. obductilis*).

Polycoccum pulvinatum (Eitner) R.Sant. (Ascomycetes: Dothideales)

The *Polycoccum* species on Physciaceae need to be further studied. Among these *P. pulvinatum* which is causing the formation of galls, mainly on saxicolous populations of several *Physcia* species, seems to be well circumscribed. It was discussed in some detail by Triebel et al. (1991). Those on crustose Physciaceae are much less known.
Distribution: Europe, Africa (Madeira, Canary Islands), Asia (Malaysia), South America (Peru, Chile), North America (Canada, Mexico, Greenland). New to Canada.
Sel. lit.: Vezda (1969, sub *P. galligenum*), Hawksworth & Diederich (1988); Alstrup & Hawksworth (1990), Triebel et al. (1991).

Specimen: **Canada. Québec.** Bas-Saint-Laurent: ca. 25 km SW of Rimouski, NE of St. Fabien, Parc du Bic, E of Montagne à Michaud Mtn, beside walking trail near the bay "Anse à Wilson". 46°21'38"N, 68°47'57"W, ca. 20 m, on bark of tree, on *Physcia aipolia* (thallus) causing galls, Rambold 6114 (M).

Roselliniella cladoniae (Anzi) Matzer & Hafellner (Ascomycetes: Sordariales)

Although the perithecia of *R. cladoniae* are relatively big, they are easily overlooked as they develop frequently on the lower parts of podetia often hidden by squamules of the primary thallus.
Distribution: Europe, Africa (Canary Islands), Asia (Mongolia, New Guinea), Australasia (Australia), North America* (U.S.A.). New to North America (U.S.A.: Maine, Vermont).
Sel. lit.: Matzer & Hafellner (1990).

Specimens: **U.S.A. Maine.** Washington Co.: Cobscook Bay State Park, Edmunds Township, on cliff overlooking Bay of Fundy, appx. 45°N, 67°W, at about sea level, in shade, on *Cladonia bacillaris* (podetia), Hammer no. 5946a, (separated from Hammer, Clad. Amer. Exs. no. 180) (GZU). **Vermont.** Bennington Co.: Green Mountain National Forest near Bondville, Winhall Township, appx. 43°N, 73°W, ca. 500 m, on rocky soil, on *Cladonia grayi* (podetia), Hammer no. 6020a (separated from Hammer, Clad. Amer. Exs. no. 201) (GZU).

Roselliniopsis tartaricola (Nyl.) Matzer (Ascomycetes: Sordariales)

Roselliniopsis tartaricola has previously been reported on *Pertusaria hemisphaerica* and *Ochrolechia* species. It is characterized by globose to ellipsoid ascospores, that are non-septate, sometimes becoming 1-septate or submuriform and often remain adhering in groups of 2–5, the size of the single spores being 10–13 x 8–10 µm.
Distribution: Europe, Africa (Canary Islands), Asia (Russia), North America* (U.S.A., Greenland). New to continental North America (U.S.A.: Arizona, Mexico).
Sel. lit.: Matzer (1993); Alstrup & Hawksworth (1990).

Specimens: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, between Phelp's cabin and the base of cliffs, mixed conifer forest including large *Pseudotsuga menziesii*, 33°55'30"N, 109°30'30"W, ca. 2800 m, on bark of *P. menziesii*, on *Pertusaria wulfenioides* (thallus), H. 36659 (GZU). **Mexico. Chihuahua.** Small ridge within Barranca del Cobre above Basihuare, 27°27'00"N, 107°29'20"W, 2000m, on corticolous *Pertusaria* sp. (thallus), N. 37254 (ASU).

Sclerococcum montagnei Hafellner (Hyphomycetes)

The species is restricted to the *Lecanora rupicola* group and was so far known only from the Mediterranean region and the British Isles.
Distribution: Europe, Africa (Canary Islands), North America* (U.S.A.). New to North America (U.S.A.: Arizona).
Sel. lit.: Hafellner (1996b).

Specimen: **U.S.A. Arizona.** Apache Co.: Apache N. F., Mt. Baldy Wilderness, valley of the East Fork of the Little Colorado River, between Phelp's cabin and the base of cliffs, mixed conifer forest including large trees of *Pseudotsuga menziesii*, on boulders of volcanic conglomerate at the edge of the forest, 33°55'30"N, 109°30'30"W, ca. 2800 m, on *Lecanora rupicola* (thallus), 3 VII. 1994, H. 36671 (herb. Hafellner).

Scutula miliaris (Wallr.) Trevis. (Ascomycetes: Lecanorales)

Scutula miliaris has been described in detail by Triebel et al. (1997). It is easiest distinguished from the other endocarpylic *Scutula* on *Peltigera*, *S. epiblastematica*, for not being so aggressively parasitic and having more dispersed apothecia.
Distribution: Europe, Africa (Kenya), Australasia (New Zealand), South America

(Chile), North America (Canada, U.S.A., Mexico, Greenland). New to Mexico.
Sel. lit.: Triebel et al. (1997); Noble et al. (1987), Alstrup & Hawksworth (1990), Goward et al. (1994), Alstrup & Cole (1998), Cole & Hawksworth (2001), Santesson (2001).

Specimen: **Mexico. Chihuahua.** Sierra Madre Occidental, narrow valley ca. 28 km NW of Basaseachic, along the road (Hwy 16) to Yepáchic, riparian area with mixed forest (including *Alnus*) and scattered boulders, 28°20'50"N, 10815'45"W, 1720 m, on boulders near the stream, on *Peltigera* sp. (thallus), H. 38832 (GZU), dupl. distributed in Santesson, Fungi Lichenicoli Exs. no 334.

Sphaerellothecium atryneae (Arnold) Cl.Roux & Triebel (Ascomycetes: Dothideales)

Triebel et al. (1991) recorded the species from the United States and Mexico, however the specimens on which these records were based have been redetermined as belonging to *Stigmidium squamariae* (de Lesd.) Cl.Roux & Triebel (Roux & Triebel 1994: 527). See also below under *Stigmidium squamariae*.
Distribution: Europe, North America* (U.S.A.). New to North America (U.S.A.: Arizona).
Sel. lit.: Roux & Triebel (1994).

Specimen: **U.S.A. Arizona.** Gila Co.: N to NE side of Four Peaks near the Maricopa Co. line, 33°40'N, 111°18'W, 2150 m, on *Lecanora swartzii* (apothecia), N. 25370 (GZU).

Sphinctrina leucopoda Nyl. (Ascomycetes: Caliciales)

This species is characterized by the clearly stalked, brown, shiny, K– apothecia, and the small (4.5–6.5 x 4–6 µm), more or less globose ascospores.
Distribution: Europe, Africa (?South Africa, Canary Islands), Australasia (Australia), Pacific Islands (Hawaii), South America (Peru), North America (U.S.A., Mexico). New to Mexico.
Sel. lit.: Löfgren & Tibell (1979), Tibell (1987, 1996), Purvis (1992); Fink (1935).

Specimens: **Mexico. Baja California.** Peninsula SW of San Quintín, coast on W side of peninsula, volcanic cliffs behind the beach, 30°28'N, 116°02'W, ca. 20 m, on *Pertusaria* sp. on rock faces exposed to the NW, H. 39337 & A. Hafellner (herb. Hafellner). **Baja California Sur.** 21 km SW of highway along road to Puerto Cancun at turnoff to Cayuco, 24°35'N, 111°45'W, 50 m, on *Lecanora caesiorubella* over bark, N. 33949 pr. p. (with *Chaenothecopsis kalbii*, det. Tibell) (ASU).

Spirographa fusisporella (Nyl.) Zahlbr. (Ascomycetes: Ostropales)

Spirographa fusisporella has narrow, 1-septate ascospores (22–)25–32(–35) x 1.5–2 µm. *Pertusaria wulfenioides* is added to the list of the hosts.
Distribution: Europe, Africa (Canary Islands), Southern America (Cuba, Brazil), North America (Canada, U.S.A.). New to Arizona.
Sel. lit.: Holien & Triebel (1996); Alstrup & Cole (1998).

Specimen: **U.S.A. Arizona.** Apache Co.: Mt. Baldy Wilderness, between Phelp's cabin and the base of cliffs, mixed conifer forest including large trees of *Pseudotsuga menziesii*, 33°55'30"N, 109°30'30"W, ca. 2800 m, on bark of *P. menziesii*, on *Pertusaria wulfenioides* (thallus), H. 36660 (herb. Hafellner).

Stigmidium epixanthum Hafellner spec. nov. (Ascomycetes: Dothideales)

Ascomata frequenter secus margines et fissuras areolarum formata, nigra, sessilia. Species differt a Stigmidio fuscatae, specie altera quae crescit supra Acarosporam, in positione pseudotheciorum, pseudotheciis maioribus superficialiter haud laevigatis, distincte sessilibus et ascosporis aliquot maioribus.

Typus: **Mexico. Baja California Sur.** Sierra de la Giganta, about 70 km NE of Ciudad Insurgentes, ca. 450 m, 25°40'N/111°16'W; semidesert scrub on NW-facing slopes, on N-facing cliffs of volcanic rock, on thalli of unidentified species of *Acarospora* subgen. *Acarospora*, 19 II. 1993, J. Hafellner 44885 & A. Hafellner (GZU–holotype. Isotypes will be distributed in Santesson, Fungi Lichenicoli Exs.)

Icon.: Fig. 4 (ascospores)

Infection without any visible effect on the thallus of the host. Intramatrical hyphae hardly discernable in thallus sections, hyaline; superficial hyphae lacking. Ascomata scattered or in irregularly small groups, prefering the edges and fissures of thallus areolae, but also occurring in groups on apothecia, sessile, black, mat, globose to obpyriform, an apical central ostiolum sometimes visible under the dissecting microscope, c. 100–140 µm high and 120–180 µm in diam.; wall of ascoma consisting of two layers (an outer layer dark brown and entirely carbonized, uneven on the outside, and an inner layer of elongated, tangentially arranged cells, laterally together c. 30 µm in diam., basally hyaline to pale brownish, composed of subglobose cells). Hamathecium rudimentarily present as branched and anastomosing physes above the asci in the ascoma cavity. Asci clavate to saccate, fissitunicate, 8-spored, 40–55 x 12–15 µm; endoascus markedly thicker in the upper half, with ocular chamber, not reacting with I or KI. Ascospores hyaline, 1-septate, upper cell slightly thicker than lower one, 13–*14.4*–16 x 5–*5.9*–7 µm, length/width ratio c. 2.4; without distinct perispore layer in LM; spore wall not reacting with Cresylblue. Pycnidia not seen.

Hosts: *Acarospora heufleriana* Körb., *A. lavicola* J.Steiner, *A. radicata* H.Magn., *A. xanthophana* (Nyl.) Jatta, *Acarospora* subg. *Acarospora* spec. div.

Etymology: epi– (greek) – upon, pointing to the characteristic sessile ascomata, xanthos (greek) – yellow, referring to the favorite group of hosts (*Acarospora* subg. *Acarospora*, syn. *Acarospora* "subg. *Xanthothallia*").

Remarks: *Stigmidium epixanthum* strongly prefers hosts belonging to *Acarospora* subg. *Acarospora* ("yellow Acarosporas"). Two other ascomycetes with perithecioid ascomata and hyaline, 1-septate ascospores are known to grow on (brown) species of *Acarospora*, *Stigmidium fuscatae* (Arnold) R.Sant. (Arnold 1872a) and *Zwackhiomyces argentinae* (Räsänen) D.Hawksw. & V.Atienza (Hawksworth & Atienza 1994). *S. fuscatae*, growing on *Acarospora fuscata* and related species, can be distinguished by its smaller, semi-immersed ascomata with smooth peridial walls which are formed in large numbers and are regularly dispersed over the surface of infested areoles. The ascospores of *S. fuscatae* measure 9–*10.7*–12 x 4–*5.0*–5.5 µm. *Z. argentinae*, a species so far only reported from southern South America, is best recognized by its persisting paraphysoids and the presence of a finely verruculose perispore.

According to a revision by the senior author those specimens cited by Triebel et al. (1991, sub *S. fuscatae*) as growing on *Acarospora schleicheri* belong to *S. epixanthum*.

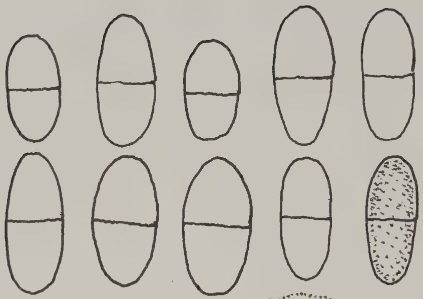
Distribution: The species is widely distributed in the drier parts of the world. It is so far known from Africa incl. Macaronesia, Australia, North America and South America.

Selected further specimens (all on *Acarospora* subg. *Acarospora* species, if no species name is given the host has been determined only to subgenus level): **Africa. Madeira.** Ponta de S.Lourenco, 5 km E von Canical, SE-exponierte Vulkanitschrofen N ober der Ponta do Buraco, 32°44'30"N, 16°41'W, ca. 50 m, an Neigungsflächen, H. 28016 & A. Hafellner (GZU). S-Küste, Ponta Garajau SW von Canico, 32°38'N, 16°50'40"W, ca. 180 m, E-exponierte Neigungsflächen niederer Vulkanitblöcke, H. 27880 & A. Hafellner (GZU). **Canary Islands.** Lanzarote. Puerto del Carmen, am W Ortsrand, 28°55'30"N, 13°39'25"W, ca. 100 m, *Launaea*-Halbwüste, auf niederen Basaltblöcken, A. Hafellner & H. 47698 (GZU). Fuerteventura: nahe der E-Küste etwa halbwegs zwischen Puerto del Rosario und Corralejo, sanft geneigte Hänge SE-seitig am Fuß des Vulkans Roja, 28°37'40"N, 13°50'05"W, ca. 50 m, Malpais, auf kleinen Lavablöcken, A. Hafellner & H. 53384 (GZU). Hügel kurz N der Degollada Cha Cabrera, W ober der Straße von La Pared nach Pájara, 28°18'00"N, 14°09'30"W, ca. 450 m, Launaea-Halbwüste mit Sukkulentenbusch-Elementen, auf kleinen Vulkanitblöcken am NE-Hang, A. Hafellner & H. 53410 (GZU). Malpais Grande E von Tuineje, 28°19'30"N, 13°56'40"W, ca. 120 m, Malpais, auf kleinen Lavablöcken, A. Hafellner & H. 53401 (herb. Hafellner). Halbinsel Jandía, im Talschluß von Gran Valle NW von Morro Jable, kurz oberhalb der Casas de Gran Valle (verfallen), 28°05'05"N / 14°23'05"W, ca. 200 m; *Launaea*-Halbwüste, auf kleinen Basaltblöcken, leg. A. Hafellner & H. 52096 (GZU). Gran Canaria. kurz N ober Fataga an der Straße nach San Bartolomé de Tirajana, 27°53'40"N, 15°34'W, ca. 750 m, Basaltschrofen im Sukkulentenbusch, auf besonnten Neigungsflächen, H. 48103 (herb. Hafellner). Tenerife. Macizo de Anaga, SW-Hang des Samáforo bei Igueste de San Andrés, 80–150 m: on *Acarospora lavicola*, O. Breuss 4284b (GZU). N-Küste, La Barranquera de Valle Guerra ca. 4.5 km NW von Tejina, 28°32'20"N, 16°23'30"W, ca. 20 m, Lavablöcke, H. 36554 & A. Hafellner (GZU). Teno-Gebirge, NW unter Teno Alto am Steig hinab zur Nordküste, hoch oberhalb von Las Casas (kurz E der Punta de Teno), 18°21'05"N, 16°54'20"W, ca. 400 m, Vulkanitschrofen im Sukkulentenbusch, H. 46433 (GZU). La Palma. SE-Abhang des Volcan Martín 4 km N Fuencaliente an der Straße nach Santa Cruz, 28°31'N, 17°48'55"W, ca. 750 m, historische Lavadecken, auf niederen Lavablöcken, H. 29437 (GZU). La Gomera. Felsrippe im unteren Teil des Lomo del Camello SW ober San Sebastian, 28°04'30"N, 17°07'W, ca. 200 m, Basalt, auf niederen Blöcken am E-Fuß der Abbrüche, H. 34450 & A. Hafellner (GZU). El Hierro. N-Küste, Arenas Blancas NW unter dem Ort Sabinosa, 27°45'55"N, 18°07'20"W, ca. 30 m, niedere Lavadecken ca. 300 m hinter dem Strand, auf Basalt in NW-Exposition, H. 45591 (GZU). La Dehesa, Montaña Tenaca, Felsköpfe am W-Abhang gegen die Montaña Quemada, 27°43'45"N, 18°08'10"W, ca. 560 m, auf Steilflächen von Basaltschrofen, H. 45592 (GZU). S-exponierte Hänge ca. 3.5 km S unter dem Ort Taibique, kurz unter dem Lomito Pardo, 27°40'15"N, 17°58'50"W, ca. 420 m, Schrofen in einer Weide, auf E-exponierten Lavabänken, H. 45593 (GZU). **Angola.** Huila, Humpata Plateau, Bimbe, alt. 2350 m, on exposed rocks, Degelius (GZU). **North America. U.S.A. Arizona.** Coconino Co.: by the road (Interstate 40) between Holbrook and Flagstaff, rest area about 2,5 km E of exit 233 (Meteor Crater Road), 35°06'20"N, 111°00'20"W, ca. 1600 m, sandstone outcrops, on rock faces exposed to NW, H. 36863, 55835 (GZU). Gila Co.: 0.5 km N of Coolidge Dam above San Carlos Lake, E-facing hillside above the road, 33°10'50"N, 110°31'50"W, ca. 870 m, rock outcrops in semidesert, on rhyolite, H. 36953 (GZU). Maricopa Co.: South Mountain Park, Phoenix, Guadalupe Canyon, 450 m, 9. II. 1987, N. & Poelt (GZU). **New Mexico.** Socorro Co.: foot of Magdalena Mts., just S of hwy 5 miles SW of Socorro, 5200 ft., on *Acarospora radicata*, Shushan S6920 & Weber (UPS, under the name of the host). **Utah.** Virgin River, on *Acarospora xanthophana*, Shushan S14493 (UPS, under the name of the host). **Mexico. Sonora.** Sierra el Caracahui, just N of Santa Eva Microndas, 32 km S of Santa Ana and 8 km E of Highway 15, 30°14'N, 111°02'W, ca. 1000 m, rocky hillside and ridge, N. & Poelt (GZU). Sierra de la Cieneguita, eastern slopes, rocky hillside 5 km N of Moctezuma, 29°46'N, 109°43'W, ca. 790 m, N. et al. (GZU). Ca. 14 km ENE of Moctezuma, by the road to Huásabas, ca. 29°50'N, 109°32'W, 960 m, low sandstone outcrops on N-facing slope, open shrubland, on inclined rock faces, H. 37627 & A. Hafellner (herb. Hafellner). Ca. 28 km E of Moctezuma, 7 km W of Huásabas, 29°55'N, 109°23'W, ca. 760 m, small cliffs of volcanic rock in open shrubland, on rock faces exposed to the N, H. 37616 & A. Hafellner (GZU). Ca. 30 km NW of Los Mochis, about 3 km NNE of Higuera de Zaragoza, W end of hill chain NW of Ahome, 26°01'N, 109°16'W, ca. 50 m, semidesert scrub with volcanic outcrops on NW-facing hillside, on small boulders, H. 40216 & A. Hafellner (GZU). Ibid., H. 40213 & A. Hafellner (GZU). Ibid., H. 40211 & A. Hafellner (herb. Hafellner). **Chihuahua.** Sierra Madre Occidental, mountain ridges W of Nuevo Casas Grandes, hills ca. 15 km SW of Janos, cliffs in desert/oak woodland transition zone, 30°41'55"N, 108°26'35"W, ca. 1500 m, on NE-facing rhyolite cliffs, H. 37105 (GZU). Sierra Madre Occidental, mountain chaines W of Nuevo Casas Grandes, foothills SW of Janos, by the road to Hacienda Casa de Adobe, 30°40'25"N, 108°29'45"W, ca. 1600 m, volcanic cliffs overlooking the valley, on rock faces exposed to the NW, H. 37144 (GZU). Ibid., H. 37142 (GZU). Ibid., H. 37139 (herb. Hafellner). Sierra Madre Occidental, mountain chains W of Nuevo Casas Grandes, foothills SW of Janos, hills NE above water reservoir, 30°39'10"N, 108°27'45"W, ca. 1620 m, scattered volcanic rocks in a pasture, on low outcrops and small boulders, H. 37132 (herb. Hafellner). **Sinaloa.** Ca. 30 km NW of Los Mochis, about 3 km NNE of Higuera de Zaragoza, W end of hill chain NW of Ahome, 26°01'N, 109°16'W, ca. 50 m, semidesert scrub with volcanic outcrops on NW-facing hillside, on small boulders, H. 40216 & A. Hafellner (GZU). **Coahuila.** 1.9 miles W of paved road at Dolores sign, on volcanic rock, on *Acarospora heufleriana*, N. 6746a (GZU). **Baja California.** Peninsula SW of San Quintín, surroundings of Cerro Kenton, small hills SW of the volcano, ca. 50 m, 30°28'N, 116°W, desert scrub , on volcanic boulders and low outcrops exposed to SW, H. 55337 & A. Hafellner (herb. Hafellner). **South America. Venezuela. Estado Merida.** an der Straße von Merida nach Tovar, zwischen Ejido und Lagunillas, ca. 900 m, Kakteensteppe, B. Oberwinkler et al. (GZU). **Australia. Northern Territory.** At the lookout on the road to Stanley Chasm, Ewart (GZU). **Queensland.** Near Stanthorpe, Storm King Dam, 28°45'S, 151°59'E, 1000 m, granite outcrops in open eucalypt woodland, Rogers 2858a (GZU).

Stigmidium fuscatae (Arnold) R.Sant. s. l. (Ascomycetes: Dothideales)

Triebel et al. (1991) and Etayo & Breuss (1998) reported *S. fuscatae* from a number of localities in Arizona, California and Mexico. However, the wide taxonomic concept applied there also included *S. epixanthum* as described above and perhaps a further *Stigmidium* on *Acarospora*-taxa with brown thalli prefering arid areas. For this reason we cite the specimens cited below as *Stigmidium fuscatae* s.l. Distribution: Europe, Africa (South Africa), North America (U.S.A., Mexico). New to Nevada.
Sel. lit.: Arnold (1872a, b); Triebel et al. (1991), Etayo & Breuss (1998).

Fig. 1 *Dactylospora pleiosperma* ascospores (holotype), pigmentation indicated in one spore.
Fig. 2 *Endococcus oreinae* ascospores (holotype), pigmentation indicated in one spore.
Fig. 3 *Plectocarpon nashii* ascospores (holotype).
Fig. 4 *Stigmidium epixanthum* ascospores (holotype).
Medium: tap water. Bar = 10 µm.



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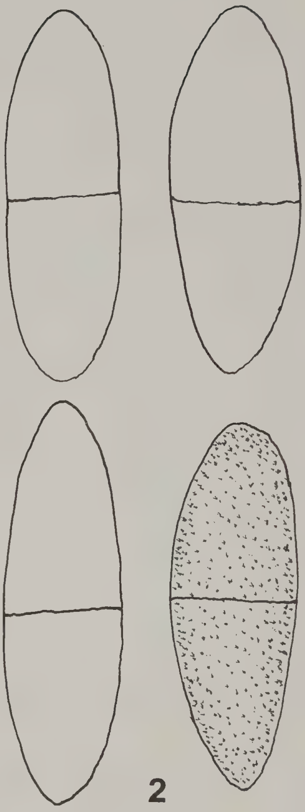

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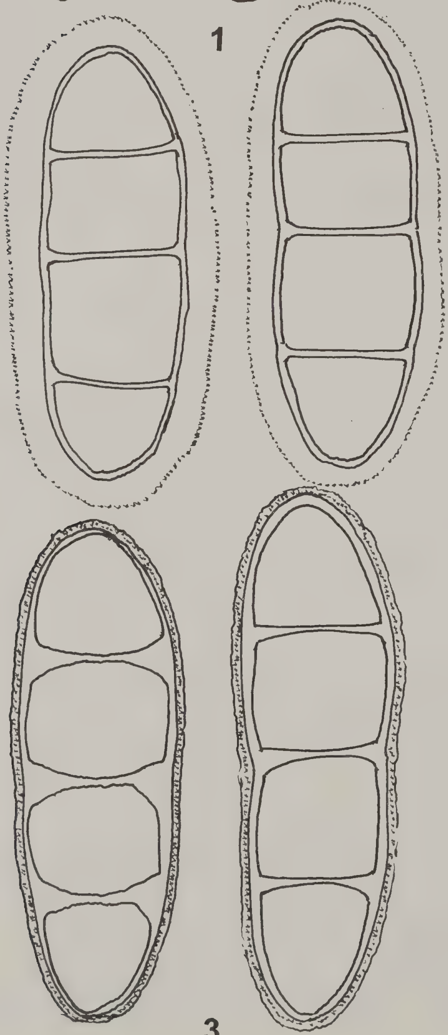

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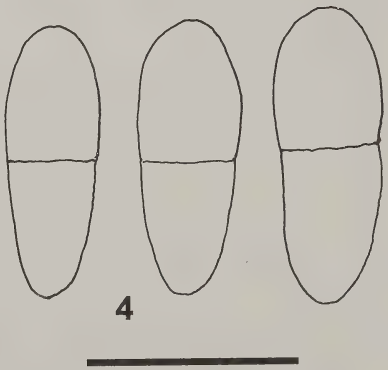

4

Specimens: **U.S.A. Arizona.** Yuma Co.: Kofa Wildlife Refuge, along dirt road to Horse Tanks, E of highway 95, 33°15'N, 114°14'W, 610 m, on *Acarospora* subgen. *Phaeothallia* spec. over acidic rock, B. D. Ryan 16040 (ASU). **Nevada.** Pershing Co.: along dirt road N of junction of Pitt Road & NV highwaz 48, 8 km NNW of Lovelock, 40°14N, 118°32W, 1280 m, on *Acarospora* subgen. *Phaeothallia* spec., Ryan (ASU). **Mexico. Baja California.** Guadalupe Island, narrow E-W canyon into the southern peak on the east side with rocky outcrops, 29°00'50"N, 118°15'50"W, 800 m, on sedimentary rock, T. H. Nash 38560 (ASU).

Stigmidium gyrophorarum (Arnold) D.Hawksw. (Ascomycetes: Dothideales)

This species is characterized beside other features by relatively large ascospores which become pale brown with age. Roux & Triebel (1994) regard it well within the generic limits of *Stigmidium*, while David & Hawksworth (in Hawksworth & Diederich 1988) included it in *Endococcus*. However, *Endococcus* is certainly not the accurate place of this species, because the ascal gel is hemiamyloid in all species of *Endococcus*, whereas it is I– in *Stigmidium gyrophorarum*.
Distribution: Europe, Asia (Russia), North America* (U.S.A.). New to North America (U.S.A.: Arizona, Colorado).
Sel. lit.: Roux & Triebel (1994).

Specimens: **U.S.A. Arizona.** Coconino Co.: San Francisco Peaks N of Flagstaff, Humphries Peak, on the ridge S below the summit, volcanic boulders and small cliffs on the ridge, 35°20'30"N, 111°40'45"W, ca. 3600 m, on protected rock faces exposed to the N, on *Umbilicaria* spec. (thallus), H. 45047 (herb. Hafellner). **Colorado.** Clear Creek Co.: Rocky Mountains, extensive N-facing talus development 1,9 km W of Silver Plume, 39°41'30"N, 105°44'W, 2845–2900 m, on *Umbilicaria* spec. (thallus), Anderson & Poelt (GZU).

Stigmidium pumilum (Lettau) Matzer & Hafellner (Ascomycetes: Dothideales)

The small ascomata develop on the older parts of the thalli of *Physcia* species. The species was recently reported from Minnesota by Cole & Hawksworth (2001).
Distribution: Europe, Australasia (New Zealand), South America (Chile), North America (U.S.A.). New to Arizona.
Sel. lit.: Matzer & Hafellner (1990); Cole & Hawksworth (2001).

Specimen: **U.S.A. Arizona.** Coconino Co.: west side of San Francisco Peaks, near road to Snow Bowl, 2680 m, on volcanic rock, together with *Arthonia epiphyscia* on *Physcia wainioi*, N. 7472 (GZU, filed under *Arthonia epiphyscia*).

Stigmidium squamariae (de Lesd.) Cl.Roux & Triebel (Ascomycetes: Dothideales)

This species has previously been regarded as identical with *Sphaerellothecium atryneae*, but has been accepted as separate species by Roux & Triebel (1994). According to these authors it is not restricted to the *Lecanora muralis* group but develops also on *Lecanora polytropa*.
Distribution: Europe, Africa (Morocco), North America (U.S.A., Mexico). New to Nevada.
Sel. lit.: Roux & Triebel (1994); Bouly de Lesdain (1909, 1914, 1933), Triebel et al. (1991, sub *Stigmidium atryneae*)

Specimen: **U.S.A. Nevada.** Pershing Co.: along dirt road N of junction of Pitt Road & NV highway 48, 8 km NNW of Lovelock, 40°14N, 118°32W, 1280 m, on *Lecanora pseudomellea* (apothecia), Ryan (ASU).

Syzygospora bachmannii Diederich & M.S.Christ. (Basidiomycetes: Tremellales)

Syzygospora bachmannii can be distinguished from the other heterobasidiomycetes growing upon *Cladonia* by its aseptate basidia. In North America it was so far known only from British Columbia.

Distribution: Europe, Africa (Madeira), Asia (New Guinea), South America (Guyana), North America (Canada, U.S.A.). New to the U.S.A. (Alaska).

Sel. lit.: Diederich (1996).

Specimen: **U.S.A. Alaska.** vicinity of Juneau, Herbert Glacier, elev. ca. 100 m, in recent first generation scrub forest, on *Cladonia phyllophora* (th.), 7. VII. 1962, H. A. Imshaug 28340a (herb. Hafellner).

Tephromela cerasina (Müll.Arg.) Rambold & Triebel (Ascomycetes: Lecanorales)

The species is restricted to *Dirinaria*, on which the apothecia occur dispersed or aggregated in small groups, and is best characterized by its small, broadly ellipsoid to subglobose ascospores (Rambold 1993). *Dirinaria confusa* var. *saxicola* (Räsänen) D.D.Awasthi is a new host lichen for this species.

Distribution: Africa (Ivory Coast), Central and South America (Brazil, Venezuela, Costa Rica), North America* (Mexico). New to North America (Mexico).

Sel. lit.: Rambold (1993).

Specimen: **Mexico. Sonora.** 5.5 km E of bridge at Huasabas, desert hillside, 1040 m, 29°55'30"N, 109°16'W, N. 25,667, on *Dirinaria confusa* var. *saxicola*, det. K. Kalb, conf. T. (ASU).

Thelocarpon lichenicola (Fuckel) Poelt & Hafellner (Ascomycetes: Lecanorales)

Thelocarpon lichenicola is known occurring on several unrelated lichens and also on free-living algae. *Icmadophila ericetorum* is reported here as a new host lichen.

Distribution: Europe, North America* (Canada, U.S.A., Greenland). New to Canada.

Sel. lit.: Salisbury (1974), Poelt & Hafellner (1975), Kocourková (2000); Alstrup & Hawksworth (1990).

Specimen: **Canada. Québec.** Manicouagan: Forêt Montmorency, SE of Réserve faunique de Laurentides, ca. 75 km NNE of Québec, region ca. 3.5 km E of the experimental station of the Université Laval, "Chute de la Rivière Noire" walk, SE of the Rivière Noire, wayside, 47°20'N, 71°06'W, ca. 700 m, on rotten tree trunk, on *Icmadophila ericetorum* (thallus), growing together with *Dactylospora attendenda* (separated), Rambold 6134 (M).

Vouauxiella lichenicola (Linds.) Petr. & Syd. (Coelomycetes)

The specimen from Mexico has slightly warted conidia of 6–8 x 3–4 µm. It is treated here as *V. lichenicola* and not as *V. verrucosa* (Vouaux) Petr. & Syd. as the ornamentation is less than 0.5 µm thick.

Distribution: Europe, Africa (Morocco, Tunisia, Madeira) Asia (Turkey), North America (U.S.A., Mexico). New for Mexico.

Sel. lit.: Hawksworth (1976, 1981); Esslinger & Egan (1995).

Specimen: **Mexico. Baja California.** Isla Cedros, north-facing slope on NE ridge top with pines at north end of the island, 28°22'N, 115°15'W, ca. 400 m, on *Lecanora*, N. 34277 (ASU).

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MYCENA PINOPHILA, A NEW SPECIES OF MYCENA SECTION POLYADELPHIA FROM SPAIN

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Summary: *Mycena pinophila sp. nov.* has been found growing on *Pinus sylvestris* needles. The dark coloured basidiomata, particular habitat and broad and densely diverticulated cheilocystidia characterize the new species. Notes on closely related species are given and a new identification key for *Mycena* sect. *Polyadelphia* including all members in the Northern Hemisphere is proposed.

Keywords: Tricholomataceae, *Pinus sylvestris,* Spanish mycota.

INTRODUCTION

The original diagnosis of *Mycena* section *Polyadelphia* Singer ex Maas Geest., includes taxa which are characterized by small basidiomata, short number of lamellae with subhorizontal to slightly concave edge, thin stipe insititious or with mycelial filaments radiating from the base, short and broad basidia with plump sterigmata and hyphae of the pileipellis densely ornamented with short warts. However, the discovery of some new species makes necessary to emend the description of this section (MAAS GEESTERANUS, 1982: 268), to enlarge the concept of the section, on account of the presence of some characters not contemplated before, like smooth cheilocystidia, smooth hyphae of the pileipellis and stipitipellis, convex lamellar-edge and deviating habitat. The whole members of this section grow on litter, decaying leaves of deciduous trees, herbaceous stems or fronds of ferns, except *Mycena pinophila* which was collected fruiting on coniferous needles.

MATERIAL AND METHODS

The description of *M. pinophila* has been made based on the examination of one collection containing ten fresh specimens in all stages of behaviour.

Figures were made with the aid of a camera lucida device. Spore measurements follow the method proposed by HEINEMANN & RAMMELOO (1985). Authors abbreviations are according KIRK & ANSELL (1992).

Mycena pinophila* M. Villarreal, Arenal & V. Rubio *spec. nov. **(Figs. 1-4)**

Basidiomata solitaria vel bina. Pileus 2-4 mm latus, parabolicus, conicus vel conico-campanulatus, translucente-striatus, e pruinoso glabrescente, griseobrunneus, margine pallidior vel albidus. Caro tenuisssima, odore saporeque indistinctis. Lamella, c. 11 stipitem attingentes, adscendentes, molles, usque ad 0,5 mm latae, subventricosae, late adnatae, dente decurrentes, albae, margine convexo. Stipes 16-22 x 0,3-0,5 mm, fragilis, aequalis, basi fibrillis longis albidique munitus.
Sporae 7,5-9 x 4,5-5,5 µm, ellipsoideae, laeves, amyloideae. Basidia 16-19 x 8-10 µm, clavata, 4-sporigera, fibulata, sterigmatibus usque ad 4 µm longis praedita. Cheilocystidia 22-35 x 19-25 µm, clavata, fibulata, surculis 2-6 x 0,8-1,1 µm. Pleurocystidia nulla. Trama lamellarum leviter dextrinoidea. Hyphae pileipellis 9-23 µm latae, fibulatae, surculis numerosis, brevibus. Hyphae stipitis corticalis diverticulatae.

Ad aciculas dejectas in silvis acerosis.

Holotypus: no AH 27007.

Basidiomata isolated or in twos. Pileus 2-4 mm in diam., parabolic, conical to conical-campanulate, without umbo, apparently smooth, slightly granular to furfuraceous under the lens, pruinose-glabrescent, dark greyish-brown at the centre, whitish-grey at the margin, translucent-striate nearly the disc, dry. Context thin. Smell and taste absent. Lamellae c. 11 reaching the stipe, lamellulae 1-3, tender, up to 0.5 mm wide, adnate to slightly decurrent by a tooth, whitish, with convex to subhorizontal, concolorous lamellar edge. Stipe 16-22 x 0.3-0.5 mm, cylindrical, equal, whitish at the upper part, greyish brown below, glabrous, with the base covered by long whitish fibrils, not forming a basal path neither basal disc.
Basidia 16-19 x 8-10 µm, broadly clavate, 4-spored, clamped at the base. Sterigmata 3-4 µm long, plump. Spores 7.50-8.38-9 x 4.50-4.74-5.33(-5.50) µm; Q = 1.50-1.77-2; (n=22), ellipsoid, smooth, strongly amyloid. Cheilocystidia 22-35 x 19-25 µm, hyaline, claviform, broadly claviform to subglobose, densely diverticulated, with simple excrescences 2-6 x 0.8-1.1 µm, clamped, turning the edge sterile. Pleurocystidia absent. Hymenophoral trama regular, weakly dextrinoid, made up of hyphae 6-15 µm wide. Hyphae of the pileipellis 9-23 µm wide, densely covered by simple warts 1-2 x 0.8-1 µm, not embedded in gelatinous material, without differentiated terminal cells. Cortical layer of the pileus parenquimatous with elements up to 35 µm broad. Hyphae of the stipitipellis 5-14 µm wide, densely diverticulated, clamped, not embedded in gelatinous material. Terminal cells absent. Cortical layer of the stipe constituted by parallel, undifferentiated hyphae 5-17 µm wide.

Habitat: on decayed needles of *Pinus sylvestris* L., under *Ilex aquifolium.*

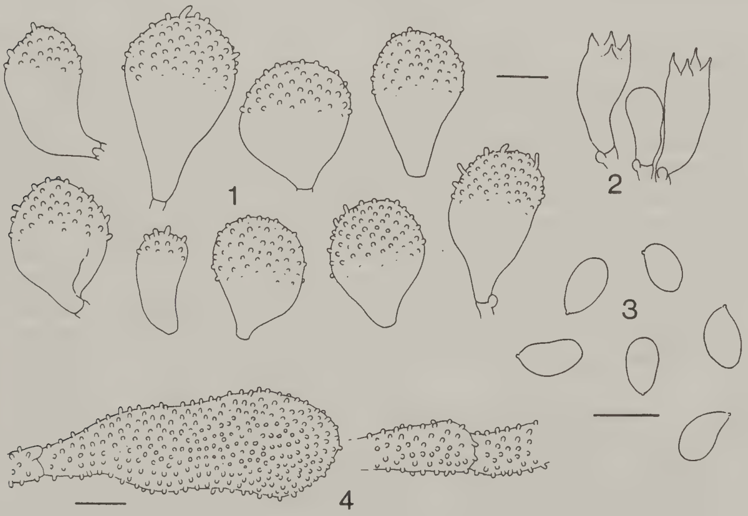
Material studied: **Spain**: *Cuenca*, Huesas del Vasallo, 23-XI-2001 L. Leg. *F. Arenal & M. Villarreal*, AH 27007 (Holotype).

DISCUSSION

Only *Mycena dasypus* Maas Geest. & Læssøe shows a similar habitat to the new taxon. This species was described from England living on litter of *Pinus sylvestris*, *Quercus* and *Rubus* (MAAS GEESTERANUS & LÆSSØE, 1992). The original description of basidiomata colours is somewhat doubtful, and consequently this taxon has been included twice in the key. Also, microscopically differs from *M. pinophila* in having narrower spores, smaller cheilocystidia apically less ornamented and conspicuously narrower hyphae of the pileipellis.

Other dark coloured species is *M. querciphila* Esteve-Rav. & M. Villarreal (as *M. quercophila*); however, this taxon shows a very distinct appearance, differing in having olivaceous tinges, presence of a basal path and fruiting exclusively on *Quercus ilex* L. leaves. Microscopically both taxa are easily distinguishable on the basis of the width and diverticulation of the cheilocystidia, being narrower and smooth to sparsely diverticulated in *M. querciphila*.

Mycena pinophila, should not be confused with *M. pinicola* Stevenson, a more robust taxon with vinaceous colours found growing in litter of *Pinus* in New Zealand (STEVENSON, 1964), and which does not belong to sect. *Polyadelphia*.



Figs. 1-4. ***Mycena pinophila*** (AH 27007, holotype). **Fig. 1.** Cheilocystidia. **Fig. 2.** Basidia. **Fig. 3.** Spores. **Fig. 4.** Hyphae of the pileipellis. Bar= 10μm.

Since MAAS GEESTERANUS (1986) published his key for *Mycena* sect. *Polyadelphia*, a total of five new species belonging to this section have been described for the European continent, two of them reported from mediterranean areas (ESTEVE-RAVENTÓS & VILLARREAL, 1997; MORENO & HEYKOOP, 2000). This fact made us to propose an actualized key for this section in the Northern Hemisphere. The key proposed below is outlined after MAAS GEESTERANUS (1986).

KEY FOR SPECIES OF *MYCENA* SECTION *POLYADELPHIA* (NORTHERN HEMISPHERE)

1. Basidiomata with pink, vinaceous, purplish or violaceous tints.
  2. Clamps present.
    3. Basidiomata growing in hygrophilous habitats, living on monocotyledonous plant debris (i.e. *Juncus*, *Carex*, *Scirpus*).
      4. Spores 8-9x4-5 µm. Cheilocystidia somewhat irregularly and asymmetrically shaped, frequently sprouting globose, diverticulate proliferations. Hyphae of the basal disc clamped with colourless cell walls:……………………….***M. juncicola***
      4. Spores 9-11x5-6 µm. Cheilocystidia regularly and symmetrically shaped, without globose proliferations. Hyphae of the basal disc clampless, with brown cell walls:…………………………………………………………….***M. culmigena***
    3. Basidiomata fruiting on different substrata.
      5. Pinkish tones only present in the lamellae. Spores 8.5-11.5x3.7-5 µm:……………………………………………………………………….***M. bertaultiana***
      5. Pinkish tones only present at the base of the stipe. Spores 7.2-9.8x3.6-4.6 µm:………………………………………………………………………….***M. dasypus***
  2. Clamps absent.
    6. Basidia 4-spored. Caulocystidia at the base of the stipe covered with fairly long, usually curved excrescences:…………………………………………………….***M. riparia***
    6. Basidia 2-spored. Caulocystidia at the base of the stipe covered with short, straight excrescences:…………………………………………………….***M. smithiana***
1. Basidiomata without these colours.
  7. Basidiomata with orange-brown, dark brown and/or olivaceous tinges when fresh.
    8. Pileus pale olive-yellow to dark gray-olivaceous. Cheilocystidia smooth or sparsely diverticulated. Occurring in dead leaves of *Quercus*:………***M. querciphila***
    8. Pileus dark grey-brown. Cheilocystidia densely diverticulated. Occurring in dead needles of *Pinus*:…………………………………………………….***M. pinophila***
  7. Basidiomata purely white, whitish to greyish white, never with brownish colours in fresh.
    9. Cheilocystidia completely smooth, growing on dead *Salix* leaves:………***M. terena***
    9. Cheilocystidia diverticulated.
      10. Spores pip-shaped to almost cylindrical.
        11. Base of the stipe attached to the substratum by a whorl of radiating mycelial hyphae or strands of hyphae.
          12. Mycelial hyphae radiating from the base of the stipe brown to almost black.
            13. Lamellae decurrent with a tooth. Stipe black:…………………***M. albiceps***
            13. Lamellae not decurrent with a tooth. Stipe dark grey-brown in very young specimens but soon pallescent, eventually whitish:……..***M. capillaris***
          12. Mycelial hyphae radiating from the base of the stipe whitish.

14. Stipe pale yellowish-brown. Spores 4.7-5.2 µm broad (-6.5 µm according to REDHEAD, 1984):..***M. lodhwagii***
14. Stipe differently coloured. Spores up to 4.5 µm broad.
    15. Cheilocystidia 14-15 µm wide, living on herbaceous debris and ferns:..***M. herbarum***
    15. Cheilocystidia 6.3-10.5 µm wide, living on *Pinus* litter and twigs of *Rubus*:..***M. dasypus***

11. Stipe insititious (base of the stipe not or hardly attached to the substratum by a whorl of radiating hyphae).
    16. Lamellae decurrent with a tooth of deeply decurrent. Stipe originally white.
        17. Spores broadly pip-shaped, up to 5 µm broad. Cheilocystidia subglobose. Found to grow in a hothouse:..............................***M. invisibilis***
        17. Spores elongated pip-shaped. Cheilocystidia clavate to obpyriform. Occurring outdoors:..***M. polyadelphia***
    16. Lamellae not decurrent with a tooth. Stipe originally dark grey-brown, pallescent, eventually whitish. Spores nearly cylindrical:..........***M. capillaris***

10. Spores broadly pip-shaped to subglobose.
    18. Pileus grey turning white, granular. Hyphae of the pileipellis with conspicuous terminal cells:..***M. quercus-ilicis***
    18. Pileus purely white, smooth. Hyphae of the pileipellis without terminal cells:..***M. truncosalicicola***

Two species previously considered into this section have been excluded. The first one, *Mycena gaultheri* A.H. Smith, was transferred to the new sect. *Testudini* Redhead & Norvell, on account of the pileipellis forming a hymenoderm and embedded in gelatinous material (REDHEAD & NORVELL, 1993). The second one, *Mycena cistophila* Moreno & Heykoop, a mediterranean taxon recently described, occurs in dead remains of *Cistus ladanifer* L. (MORENO & HEYKOOP, 1998). Macroscopically this taxon does not differ from other *Polyadelphia* species. However, after the revision of the type collection, together with two samples collected in Portugal and Central Spain respectively, we consider that the presence of a glutinous stipe in fresh condition, pileipellis and stipitipellis embedded in gelatinous material, absence of wide hyphae of the pileipellis and the presence of some scarce pleurocystidia, are features enough reasonable to exclude *M. cistophila* from the concept of sect. *Polyadelphia* and transfer it to sect. *Cinerellae* Singer ex Maas Geest.

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MOLECULAR PHYLOGENY OF TROPICAL HYMENOCHAETALES (BASIDIOMYCOTA)

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ABSTRACT

The present work encompasses the investigation of phylogenetic relationships of 11 species of tropical Hymenochaetales through cladistic methodology using unweighted and weighted maximum-parsimony, outgroup polarization of characters, and branch-and-bound algorithm for the search of equally most parsimonious trees. The data set comprises the complete sequencing of the D3 divergent domain of the nuclear gene that codes for the 25S large subunit of ribosomal RNA. The parsimony analyses corroborates the ingroup monophyly (Hymenochaetales), the sister group relationship between Hymenochaetales and *Trichaptum*, and the polyphyletism of *Phellinus* and the *Phellinus rimosus* species complex. These findings suggest that incrusted hymenial cystidia (*Trichaptum*) and hymenial setae (Hymenochaetales) are homologous structures. The presence of many short branches in the phylogeny is presumed to be related to cladogenetic events separated by short periods of time. Thus the large number of current tropical species of *Phellinus sensu lato* may be of recent origin.

KEY WORDS: Hymenochaetaceae, cladistics, ribosomal DNA, D3 divergent domain

INTRODUCTION

Based on the presence of a peculiar type of cystidia in the hymenium of several Homobasidiomycetes, Patouillard (1900) erected his "Série des Igniaires", which united genera of different hymenial configurations and basidiome shape, thus breaking with the Friesian tradition (Fries, 1874). This taxonomic category became the nucleus of a new subfamily, Hymenochaetoidae Donk, proposed by Donk (1931, 1933) three decades later. This subfamily included all homobasidiomycete genera bearing hymenial setae.

Later, Donk (1948), enlarged the concept by the inclusion of members of Patouillard's "Série des Astérostromes" (Patouillard, 1900) as well as taxa of Vararioideae Donk (Donk, 1931), and proposed the family Hymenochaetaceae

Donk. In the same year Corner (1948) suggested his "Xanthochroic Series", which included all aphyllophoroid taxa with positive xanthocroic reaction, regardless of possessing setae or not, emphasizing that, even in the absence of setal elements, the xanthochroic reaction were shared by all representatives of the group. Subsequently, Corner (1950) also included *Clavariachaete* Corner in Xanthocroic Series, suggesting a new order, Xanthochroales.

In the classification system proposed by Donk (1964), Hymenochaetaceae was composed by three subfamilies: (i) Asterostromatoideae Donk, with only one genus, *Asterostroma* Massee, (ii) Vararioideae Donk, composed of *Vararia* P. Karsten and *Lachnocladium* Lév., and (iii) Hymenochaetoideae Donk, embracing all other genera traditionally derived from "Série des Igniaires" (Patouilliard, 1900) as well as *Asterodon* Pat. One year later Reid (1965) proposed a new family, Lachnocladiaceae Reid by merging the subfamilies Vararioideae Donk and Asterostromatoideae Donk with the inclusion of *Dichantarellus* Corner, *Scytinostroma* Donk, and the new genus *Dichopleuropus* Reid, so that *Asterostroma* Massee and genera bearing dicohyphydia were removed from Hymenochaetaceae Donk. The accepted order Hymenochaetales Oberwinkler (Oberwinkler, 1977) corresponds essentially to the subfamily Hymenochaetoidae Donk (Donk, 1964) while Lachnocladiales Jülich is Lachnocladiaceae Reid raised to ordinal rank (Jülich, 1981).

Pouzar (1983) erected the monotypic family Asterostromataceae Pouzar to accommodate *Asterostroma* Massee, which, in fact, corresponded to the elevation of Asterostromatoidae Donk (Donk, 1964) to familial rank. He also suggested that Asterostromataceae Pouzar was phylogenetically closer to Lachnocladiaceae Reid, and explicitly excluded *Asterodon* Pat., pointing out that asterosetae of *Asterodon* Pat and *Asterostroma* Massee were not homologues. Studying basidiome structure in Lachnocladiales and Hymenochaetales, Pegler and Young (1993) redefined these two orders, and reassigned *Asterostroma* Massee to Hymenochaetales, suggesting that, contrary to Pouzar (1983), asterosetae of *Asterostroma* Massee and *Asterodon* Pat. were, in fact, homologous structures. So Pegler and Young (1993) proposed a classification scheme in which the order Hymenochaetales Oberwinkler was composed by two families, Asterostromataceae (Donk) Pouzar, including *Asterostroma* Massee and *Asterodon* Pat. and Hymenochaetaceae Donk, comprising all other known Hymenochaetales. The classification scheme of Pegler and Young (1993) was accepted and incorporated in the prestigious Ainsworth and Bisby's Dictionary of the Fungi (Hawksworth et al.,1995).

It is far from consensus to include all asterosetal Homobasidiomycetes in a sole taxonomic category. Several authors (Parmasto, 1970; Oberwinkler, 1977; Hallenberg, 1985) considered *Asterostroma* Massee as a member of Lachnocladiaceae Reid, restricting *Asterodon* Pat. to Hymenochaetaceae Donk. Furthermore, it was demonstrated that *Asterostroma* Massee has dolipores with perforate septal pore cap (SPC), which is in marked contrast with all known Hymenochaetales since they all possess dolipores with imperforate SPC (Muller et al., 2000). Recently, Wagner (2001), based on 25S rDNA molecular phylogeny, pointed out that *Asterodon* Pat. and *Asterostroma* Massee are not closely related. Both Muller et al. (2000) and Wagner (2001) placed *Asterostroma* Massee in Lachnocladiales Jülich and *Asterodon* Pat. in Hymenochaetales Oberwinkler. Thus, not only ultrastructure but also molecular data indicate that *Asterostroma* Massee is not a representative of Hymenochaetales. Hence, at present time, one of the following suggestions, in terms of classification, seems reasonable: (i) Hymenochaetales with a single family, Hymenochaetaceae, including *Asterodon* Pat. or, alternatively, (ii) Hymenochaetales with two families, one for the single asterosetal representative (*Asterodon* Pat.), a monotypic family that could be denominated Asterodonaceae, and another for non-asterosetal representatives, Hymenochaetaceae *s. str.*

Therefore, based on previously discussed issues, the order Hymenochaetales Oberwinkler is regarded to be characterized by the presence of setoid structures (setae and asterosetae), euhymenial development, permanent positive xanthochroic reaction and generative hyphae without clamp-connections, comprising, at least, 13 genera: *Aurificaria* Reid, *Clavariachaete* Corner, *Coltricia* Gray, *Coltriciella* Murr., *Cyclomyces* Kunze ex Fries, *Hydnochaete* Bres., *Hymenochaete* Lév., *Inonotus* Karst., *Phellinus* Quél., *Phylloporia* Murr., *Pyrrhoderma* Imazeki, *Stiptochaete* Ryv. and *Asterodon* Pat.

Species of Hymenochaetales are white-rot wood-decay fungi, saprobes or facultative/obligate parasites of trees or, more rarely, facultative ectomycorrhizal as *Coltricia perennis* (L.) Murrill, and most of the taxa are of tropical distribution (Hawksworth et al., 1995; Ryvarden 1991, 1993).

The circumscription of hymenochaetacean genera is rather imprecise even in the realms of traditional systematics (Corner, 1991). The same situation occurs at the generic level, notably in *Phellinus* Quél., which accounts for more than half of total number of species of Hymenochaetales. That genus includes several species complexes and it is generally regarded as polyphyletic (Ryvarden, 1991; Fischer, 1996). Thus, the great taxonomic challenge is to delimit monophyletic groups inside *Phellinus* and in Hymenochaetaceae.

Comprehensive phylogenetic studies specifically concerning Hymenochaetales include those of Fiasson and Niemelä (1984) and Wagner and Fischer (2001). The former comprised a cladistic (as well as a phenetic) analysis of European poroid taxa based on morphology, biochemistry of secondary metabolites and protein-based molecular methods, and the latter encompassed a parsimony (cladistic) and neighbor joining analyses of molecular sequencing data.

Fiasson and Niemelä (1984) proposed two new suborders, Phaeolinae Fiasson & Niemelä and Hymenochaetinae Fiasson & Niemelä, the former comprising one family, Phaeolaceae Jül., and the latter, three families, Hymenochaetaceae Donk., Inonotaceae Fiasson & Niemelä and Phellinaceae Jül. The family Phaeolaceae encompassed *Coltricia* Gray and *Phaeolus* Pat., but the latter genus is currently not considered to be a hymenochaetalean representative (Hibbett and Donoghue, 1995; Boidin et al., 1998; Wagner and Fischer, 2001). The family Hymenochaetaceae contained the non-poroid genera *Asterodon* Pat., *Hydnochaete* Bres. and *Hymenochaete* Lév. The genera *Inonotus* Karst. *s. str.*, *Inocutis* Fiasson & Niemelä and *Phylloporia* Murr. were placed in the family Inonotaceae Fiasson & Niemelä. The family Phellinaceae comprised *Onnia* Karst., *Inonotopsis* Parm. and seven genera derived from the original *Phellinus* Quél.: *Fomitiporia* Murr. (*P. robustus* complex), *Porodaedalea* Murr. (*P. pini* complex), *Ochroporus* J. Schroet, (*P. igniarius* complex), *Fulvifomes* Murr. (*P. rimosus* complex), *Phellinidium* (Kotl.) Fiasson & Niemelä (*P. ferrugineofuscus* and its allies), *Fuscoporia* Murr. (*P. ferreus* and its allies) and *Phellinus* Quél. *s. str.* (*P. torulosus*).

Similar to Fiasson and Niemelä (1984), Wagner and Fischer (2001) performed a phylogenetic study of European poroid Hymenochaetales but, differently from the former authors, they utilized molecular sequence data obtained from the 5' end portion of nuclear ribosomal DNA. Their main results were as follows: (a) *Coltricia* Gray and *Onnia* Karst. were confirmed as separate genera; (b) *Phaeolus schweinitzii* was placed outside of the Hymenochaetales; (c) five groups of taxa were distinguished in *Phellinus s. lat.* based on a combination of molecular and non-molecular characters, *Fomitiporia* Murr. (*P. robustus* complex), *Porodaedalea* Murr. (*P. pini* complex), *Phellinidium* (Kotl.) Fiasson & Niemelä (*P. ferrugineofuscus* and its allies), *Fuscoporia* Murr. (*P. ferruginosus* and relatives), and *Phellinus* Quél. *s. str.* (*P. igniarius* complex); (d) five groups of taxa were also distinguished in *Inonotus* Karst.: *Inonotus* Karst. *s. str.*, *Inocutis* Fiasson & Niemelä, *Mensularia* Lazaro, *Pseudoinonotus* T. Wagner & M. Fischer *gen. nov.*, and *Inonotopsis* Parm.

Several molecular phylogenetic studies on Basidiomycota, based on DNA sequencing, were carried out in the last two decades. With the exception of aforementioned Wagner and Fischer (2001) study, Wagner and Ryvarden (2002) and Wagner and Fischer (2002), other molecular phylogenetic works did not specifically focus on Hymenochaetales, but frequently included hymenochaetalean taxa in their analyses (Hibbett and Donoghue, 1995, Hibbett et al. 1997, Ko et al., 1997, Boidin et al., 1998: Hibbett et al., 2000; Hibbett and Donoghue, 2001). All these works utilized ribosomal DNA sequences of either mitochondrial or nuclear origin.

As well as in other eukaryotes, fungal nuclear ribosomal RNA genes (5S, 18S, 5.8S and 25S) are organized in one repeating unit, present in multiples copies in genome (Hillis and Dixon, 1991). These genes have been widely used to infer fungal molecular phylogenies mainly because of their peculiar mosaic pattern of conserved and variable regions that, besides facilitating alignment, making them suitable for taxonomic investigations at different levels of generality (Bruns et al., 1991).

The 25S gene codes for a structural ribosomal RNA, which is one of the components of the large subunit of a fungal ribosome. Although most of large subunit rRNA secondary structure are composed of a common conserved core, there are interspersed divergent domains of considerable sequence variation that accounts for the large variations in size among eukaryotes. Moreover, the divergent domains themselves exhibit highly conserved or hypervariable regions (Michot et al., 1984, 1990).

In spite of current widely use of large subunit ribosomal DNA sequences in phylogenetic studies, there has not been given enough attention to the utility of the different divergent domains in this gene for phylogenetic analysis. Studying phylogenetic relationships in *Coprinus* (Agaricales, Basidiomycota), Hopple and Vilgalys (1999) demonstrated striking differences in the amount of variation of primary structure (sequence) and quality of phylogenetic signal among seven distinct divergent domains of the gene that codes for 25S rRNA.

Although the D3 divergent domain was not the most divergent, it was the only domain which contained enough signal to produce the same topology as the combined data, suggesting that shorter DNA regions containing a divergent domain, which provides adequate signal for phylogenetic analysis, are as good as or even better than longer sequences for analyzing evolutionary relationships of a given group of fungi.

In the present study the whole D3 divergent domain of 25S nuclear ribosomal RNA gene was used to infer phylogenetic relationships among some tropical Hymenochaetales taxa, through equally and unequally weighted maximum-parsimony analysis. The following questions are addressed by this study: (i) Is Hymenochaetales monophyletic?; (ii) Is *Trichaptum* the sister group of Hymenochaetales?; (iii) Is *Phellinus* monophyletic?; (iv) Is *Phellinus rimosus* species complex (*Fulvifomes* Murr.) monophyletic?

MATERIAL AND METHODS

Taxonomic Sampling

The choice of taxa for phylogenetic analysis was based on the classification scheme of Fiasson and Niemelä (1984). At least one taxon of each family (with the exception of Phaeolaceae) was represented in our analysis: Hymenochaetaceae [1 sp.] (*Hymenochaete* [1 sp.]); Inonotaceae [2 spp.] (*Aurificaria* [1 sp.], *Phylloporia* [1 sp.]); Phellinaceae [7 spp.] (*Fulvifomes* [4 spp.], *Fuscoporia* [1 sp.], *Fomitiporia* [1 sp.], *Phellinus* s. str. [1 sp.], and *Phellinus s. lat.* [1 sp. of uncertain affinity]).

The family Phellinaceae is more represented than the others because of two main reasons: (i) it groups most of known species of Hymenochaetales; (ii) to test the monophyly of *Phellinus rimosus* species complex (*Fulvifomes* Murr.), which, besides presenting a high species richness in Neotropical region (Larsen and Cobb-Poule, 1990), it was not studied by either Fiasson and Niemelä (1984) or Wagner and Fischer (2001).

A *Trichaptum* species was included among the terminals since this genus is either a likely sister group of Hymenochaetales (Ko et al., 1997), or is part of the ingroup (Hibbett and Donoghue, 1995; Hibbett et al. 1997; Hibbett et al., 2000). For rooting purposes, a Polyporaceae species (*Datronia*) as well as an Heterobasidiomycete (*Auricularia*) representative were also included: the former as a possible outgroup for Hymenochaetaceae and *Trichaptum*, and the later as a functional outgroup of *Datronia*, Hymenochaetaceae, and *Trichaptum*, comprising the highest level of generality, for Auriculariales is supposed to be the sister group of Homobasidiomycetes (Tehler et al. 2000). Thus, outgroups were selected in order to represent different levels of hierarchically nested groups (Eldredge and Cracraft, 1980). Both outgroup and ingroup taxa were collected during field trips in Brazil, and studied specimens were deposited in HUEFS and FLOR herbaria. All the terminals used in this study are listed in Table 1.

Table 1: Terminal taxa studied

Taxon	Classification based on Fiasson and Niemelä (1984)	Voucher HUEFS	GenBank accession no.
Auricularia polytricha (Mont.) Sacc.		41500	AF450265
Datronia caperata (Berk.) Ryvarden		41462	AF450254
Trichaptum byssogenum (Jungh.) Ryvarden		41457	AF450253
Aurificaria luteoumbrina (Romell) D.A.Reid	*Inonotus s. lat.*	41459	AF450252
Hymenochaete sallei Berk. & M.A. Curtis	*Hymenochaete s. lat.*	41470	AF450258
Phellinus apiahynus (Speg.) Rajchenb. & J.E. Wright	*Fomitiporia* (*P. robustus* complex)	41790	AF450264
Phellinus extensus (Lév.) Pat.	*Phellinus* sp. of uncertain affinity	41469	AF450257
Phellinus gilvus (Schwein.) Pat.	*Phellinus s. str.*	41465	AF450255
Phellinus grenadensis (Murrill) Ryvarden	*Fulvifomes* (*P. rimosus* complex)	42789	AF450263
Phellinus melleoporus (Murrill) Ryvarden	*Fulvifomes* (*P. rimosus* complex)	41471	AF450259
Phellinus membranaceus J.E. Wright & Blumenf.	*Fulvifomes* (*P. rimosus* complex)	41499	AF450260
Phellinus palmicola (Berk. & M.A. Curtis) Ryvarden	*Fuscoporia* (*P. ferreus* complex)	42783	AF450261
Phellinus rimosus (Berk.) Pilát	*Fulvifomes* (*P. rimosus* complex)	41468	AF450256
Phylloporia pectinata (Klotzsch) Ryvarden	*Phylloporia s. lat.*	42787	AF450262

Genomic DNA Extraction

DNA was extracted directly from frozen field basidiome collections. In order to avoid contamination with microorganisms on superficial portions of basidiomata, only the internal parts were utilized. Bits of basidiome (50-60 mg) were ground with a pestle in a porcelain mortar containing liquid nitrogen. Then the resulting powder was transferred to a 1.5-mL microcentrifuge tube with extraction buffer. Both a modified CTAB (100 mM Tris-HCl pH 8, 1,4 M NaCl, 2% CTAB, 20 mM EDTA, 1 % PVP) (Rogers and Bendich, 1985) or SDS (50 mM Tris-HCl, pH 7.2, 3% SDS, 1% 2-mercaptoetanol) (Lee and Taylor, 1990) extraction buffers were used. In CTAB-based procedure DNA was extracted once with chloroform-isoamyl alcohol (24:1), precipitated with isopropanol, washed with ethanol 70% and resuspended in sterilized deionized water. In SDS-based procedure chloroform-isoamyl alcohol is substituted for phenol-chloroform (1:1). Quality and quantity of DNA was assayed by means of 1% agarose gel electrophoresis, using a high weight DNA mass ladder, and of UV light spectrophotometry (260 and 280 nm).

In Vitro Amplification of Target Sequence (PCR)

Double-stranded symmetric PCR reactions were performed by using a Perkin-Elmer Cetus DNA thermal cycler (Saiki et al., 1988). Reactions were carried out in 0.2-ml tubes in 100 μl reaction volume, containing the following components: 10 mM Tris-HCl, 2.5 mM $MgCl_2$, 200 μM dNTP, 1 pmol/μl of each oligunucleotide primer, 0.02 U/μl Taq DNA polymerase and approximately 1 ng/μl genomic DNA template. Cycle parameters were according to Gardes and Bruns (1993): an initial denaturation at 94° C for 1 min 25 s, followed by 35 cycles of denaturation at 95°C for 35 s, annealing at 55°C for 55 s, and extension at 72°C for 2 min, with a final extension at 72°C for 10 min. Negatives controls, without DNA template, were prepared in every series of amplification in order to exclude the possibility of contamination in reagents or reaction buffers. The primers used for the amplification of the 5' end of 25S nuclear ribosomal RNA gene consisted of the forward primer LR0R (5'-ACCCGCTGAACTTAAGC-3') and the reverse primer LR7 (5'-TACTACCACCAAGATCT-3') (Moncalvo et al., 2000). Usually 5 μl of each PCR reaction were electrophoresed on 1% agarose gels, and DNA molecular weight marker (Amersham-Pharmacia Biotech, KiloBase DNA Marker) was used as standard. PCR was utilized to amplify a fragment of about 1.5 Kb homologous to a region in *Saccharomyces cerevisae* rDNA from base position 26 to base position 1448 in the 25S nuclear large subunit ribosomal RNA (Georgiev et al, 1981; Moncalvo et al., 2000). Double-stranded PCR products were purified by isopropanol and 10 M ammonium acetate precipitation, washed three times in 85% ethanol and resuspended in sterilized deionized water. The concentration of amplified fragments was estimated by 1% agarose gel electrophoresis and adjusted to approximately 10 ng/μl.

Sequencing

Purified PCR products were used directly for the sequencing procedures. Oligonucleotide reverse primer LR5 (5'-TCCTGAGGGAAACTTCG-3'), which aligns to positions 964-948 in the 25S rRNA in *Saccharomyces cerevisae*, was used as the sequencing primer (Moncalvo et al., 2000). DNA was labeled with a BigDye Terminator Cycle Sequencing Ready Reaction Kit (Applied Biosystems). Each 10 μl reaction consisted of 4 μl of terminator mix, 3.5 μl of sterilized deionized water, 0.5 μl (5 pmoles/μl) of primer, and 2 μl (10 ng/μl) of DNA template. Sequences were determined in an ABI Prism 377 automatic sequencer (Perkin-Elmer) using 5 % acrylamide gels (Long Ranger Singels, FMC). Sequences chromatograms were analyzed by eye and sequences edited using Chromas version 1.45 (Technelysium Pty Ltd.). The sequences were deposited in GenBank database under accession numbers indicated in Table 1.

After editing, sequences were aligned using MegAlign version 4.00 (DNASTAR Inc.), followed by manual adjustments using the same program. The more stable alignment under different conditions (penalties for mismatches, single and contiguous gaps) was selected. Hypervariable regions, that is, ambiguous aligned regions with high proportion of gaps, were excluded. Thus, problems with homology assessment, and, consequently, generation of doubtful phylogenetic information were avoided.

Phylogenetic Signal

The software RASA, *Relative Apparent Synapomorphy Analysis*, is a statistical method (*tRASA*), based on regression analysis, which tests the presence of phylogenetic signal in data set inferring the slope (β_{obs}) that represents the covariation between the apparent cladistic similarity (RAS) and the phenetic similarity (E) observed between pairs of taxa, and compares it with a null slope (β_{nul}) expected under a equiprobable model (Student's *t* distribution). So a measure of the phylogenetic signal, which is independent of the topology, is obtained. This topological-independent procedure avoids a circular reasoning that occurs in topological-dependent statistical methods, which are based on topologies previously selected by some approach, so that they are inexorably linked to the assumptions of the algorithm that searches for the most parsimonious tree(s) (Lyons-Weiler et al., 1996). Consequently, before the accomplishment of phylogenetic analysis, RASA was used in order to evaluate the phylogenetic signal of the observed data derived from D3 divergent domain of 25S rDNA.

Phylogeny Estimation

Parsimony analyses were performed with PAUP version 4.0b6 (Swofford, 1998), maintaining three parameters constant: (1) all characters of type unordered, for there is no discernable basis for coding any transformation series *a priori* (Hauser and Presch, 1991); (2) indels as a fifth character state; (3) searches using the *branch-and-bound* method (Hendy and Penny, 1982) to seek equally most parsimonious trees since it is still possible to find the minimum tree(s) without evaluating all tree topologies (Kitching, 1992).

Two distinct analyses were then conducted: (a) unweighted or equally weighted parsimony analysis, in which equal weights are attributed to all kinds of nucleotide substitutions, and (b) weighted or unequally weighted parsimony analysis, in which distinct weights are attributed to different kinds of nucleotide substitutions.

Weighted parsimony analysis was also performed since some kinds of nucleotide substitutions have a higher frequency of occurrence (e.g. transitions > transversions). Therefore, some characters are more prone to homoplasy than others and, supposedly, are less phylogenetically informative, which could result in distortions in phylogeny resolution (Swofford et al., 1996; Page and Holmes, 1998).

In order to avoid an arbitrary weighting scheme as well as a circular reasoning in the estimate of the values starting from a given tree, substitution frequencies were calculated through pairwise comparison of all 14 sequences in the data matrix. The weights were calculated as follows: $\mathbf{K}_{ij} = -\ln(\mathbf{X}_{ij}/\mathbf{X})$ **(1)**, where $\mathbf{K}_{ij}$ is the cost from going from nucleotide ***i*** to ***j*** or from ***j*** to ***i***, $\mathbf{X}_{ij}$ is the observed number of reciprocal changes between ***i*** and ***j***, and **X** is the total number of changes of all possible pairwise combinations of the 14 taxa in the data matrix. Then weights for each substitution type were averaged across all comparisons and scored as a step matrix (Cunningham, 1997, Moncalvo et al., 2000).

Clade robustness was assessed using five distinct indicators: (i) total number of apomorphies (apparent synapomorphies, primary homology hypotheses *sensu* de Pinna, 1991), (ii) total number of synapomorphies (secondary homology hypotheses *sensu* de Pinna, 1991), (iii) decay or support index (Bremer, 1988, 1994; Donoghue et al., 1992), (iv) bootstrap proportions (Felsenstein, 1985), and (v) jackknife proportions (Farris et al., 1996). Decay indices and jackknife proportions were calculated with SEPAL version 1.4 (Salisbury, 2000). Trees were edited using COMPONENT version 2.0 (Page, 1993) and WINCLADA version 0.9.99 (Nixon, 1999).

The alignment for the 14 studied taxa and the strict consensus tree associated with phylogenetic analyses were deposited within TreeBase (www.herbaria.havard.edu/treebase).

RESULTS AND DISCUSSION

RASA

The D3 divergent domain (sites 76-192) exhibited a positive value of tRASA of 2,311, significant for α = 0,05, gl=35, using the following parameters: (i) indel as a fifth character and (ii) *Auricularia polytricha*, *Datronia caperata* and *Trichaptum byssogenum* as outgroups. This indicates that the data matrix based on the sequencing of the D3 divergent domain has natural cladistic hierarchy (phylogenetic signal) and can be used for phylogenetic inference.

Phylogenetic Analyses

The aligned nucleotide sequences of D3 divergent domain across all taxa were 117 positions long. An ambiguous aligned region, containing 10 characters, was removed from the analyses as previously mentioned. Thus, of the remaining 107 characters, 62 were constant, 25 were parsimony uninformative and 20 were parsimony informative characters.

The final result of both unweighted and weighted parsimony analyses was identical: it corresponded to 11 equally most parsimonious unrooted trees with 71 evolutionary steps, with a consistency index (CI) = 0,77, a retention index (RI) = 0,53, and a rescaled consistency index (RC) = 0,41.

After the rooting, the 11 equally most parsimonious trees exhibited the following phylogenetic relationships in common: (a) a sister group relationship between *Trichaptum byssogenum* and Hymenochaetales, (b) the monophyly of Hymenochaetales, (c) the clade (*Phellinus gilvus*, *Phellinus palmicola*), (d) the clade (((*Aurificaria luteoumbrina, Phellinus rimosus*) *Phylloporia pectinata*) *Phellinus grenadensis*), and the respective less inclusive clades ((*Aurificaria luteoumbrina, Phellinus rimosus*) *Phylloporia pectinata*) and (*Aurificaria luteoumbrina, Phellinus rimosus*), as could be visualized in strict consensus tree (Fig. 1). The six putative monophyletic groups were denominated as clades A, B, C, D, E, F. In Tables 2, 3, 4 are described, for the strict consensus tree, respectively: (i) consistency (CI), retention (RI) and rescaled consistency (RC) indexes for each character, (ii) the list of synapomorphies derived from unambiguous optimization, and (iii) the five different indicators of clade robustness.

Trichaptum appears as the sister group of Hymenochaetales, coinciding with the results of Ko et al. (1997), whose work was based on 18S rDNA sequencing. The presence of imperforate septal pore cap (SPC) is the most notable similarity between *Trichaptum* and Hymenochaetales. This is a rare condition in Homobasidiomycetes (Langer and Oberwinkler, 1993; Moore, 1985), however, it is frequently found in Heterobasidiomycetes (Lü and

Mclaughlin, 1991; Wells, 1994), as, for example, in the representative of one of the outgroups in current study, *Auricularia polytricha.* Although the septal ultrastructure is known in only few Basidiomycota taxa, it is reasonable to suppose that the presence of imperforate SPC in both *Trichaptum* and Hymenochaetales is a reversion, admitting that this state is plesiomorphic for Homobasidiomycetes as suggested by Hibbett and Donoghue (1995).

In molecular studies of both mitochondrial rDNA (Hibbett and Donoghue, 1995) and nuclear rDNA (Hibbett et al., 1997; Hibbett et al., 2000; Hibbett and Donoghue, 2001) embracing several groups of Homobasidiomycetes, *Trichaptum* grouped together with species of Hymenochaetaceae *sensu stricto.* If the sister group relationship between *Trichaptum* and Hymenochaetales is true, the incrusted hymenial cystidia of *Trichaptum* and the hymenial setae of Hymenochaetales can be considered as homologous structures. The clade A (*Trichaptum*, Hymenochaetales) is supported by 3 synapomorphies (Table 3) with a decay index of 1 and bootstrap and jackknife values of 51% and 52%, respectively (Table 4).

As well as the sister group relationship between *Trichaptum* and Hymenochaetales, the ingroup (Hymenochaetales) is monophyletic in all the 11 equally most parsimonious trees. The monophyly of Hymenochaetales is in total agreement with the classification based on morphology (Oberwinkler, 1977). The clade B (Hymenochaetales) was sustained by 3 synapomorphies (Table 3) with a decay index of 1 and an identical value (45%) for both bootstrap and jackknife (Table 4).

The clade C, formed by *Phellinus palmicola* and *Phellinus gilvus*, is also present in all the most parsimonious trees. Fiasson and Niemelä (1984) considered *Phellinus gilvus* and *Phellinus torulosus* as representatives of *Phellinus s. str.,* and, according to their classification scheme, *Phellinus palmicola* can be considered as a species of *Fuscoporia* Murr. (*Phellinus ferreus* complex). According to Fischer (1996), *Phellinus torulosus*, the temperate counterpart of *Phellinus gilvus*, is closer to *Phellinus ferreus* (*Fuscoporia* Murr.) than other *Phellinus.* Furthermore, Wagner and Fischer (2001) positioned *Phellinus torulosus* within *Fuscoporia* Murr. Therefore, the close relationship between *Phellinus gilvus* and *Phellinus palmicola* coincides with the results found by Fischer (1996) and Wagner and Fischer (2001). The clade C is corroborated by 1 synapomorphy (Table 3) with a decay index of 1 and bootstrap and jackknife values of 48% and 47%, respectively (Table 4).

The clade D (((*Aurificaria luteoumbrina, Phellinus rimosus*) *Phylloporia pectinata*) *Phellinus grenadensis*) also appeared in all 11 equally most parsimonious trees, and it is supported by 1 synapomorphy (Table 3) with a decay index of 1 and bootstrap and jackknife values of 19% and 8%, respectively (Table 4). This clade is represented by Hymenochaetales without hymenial setae, with pileate basidiomata, poroid hymenophoral configuration, and colored, thick-walled spores, including representatives of three genera, *Phellinus*, *Phylloporia* and *Aurificaria.*

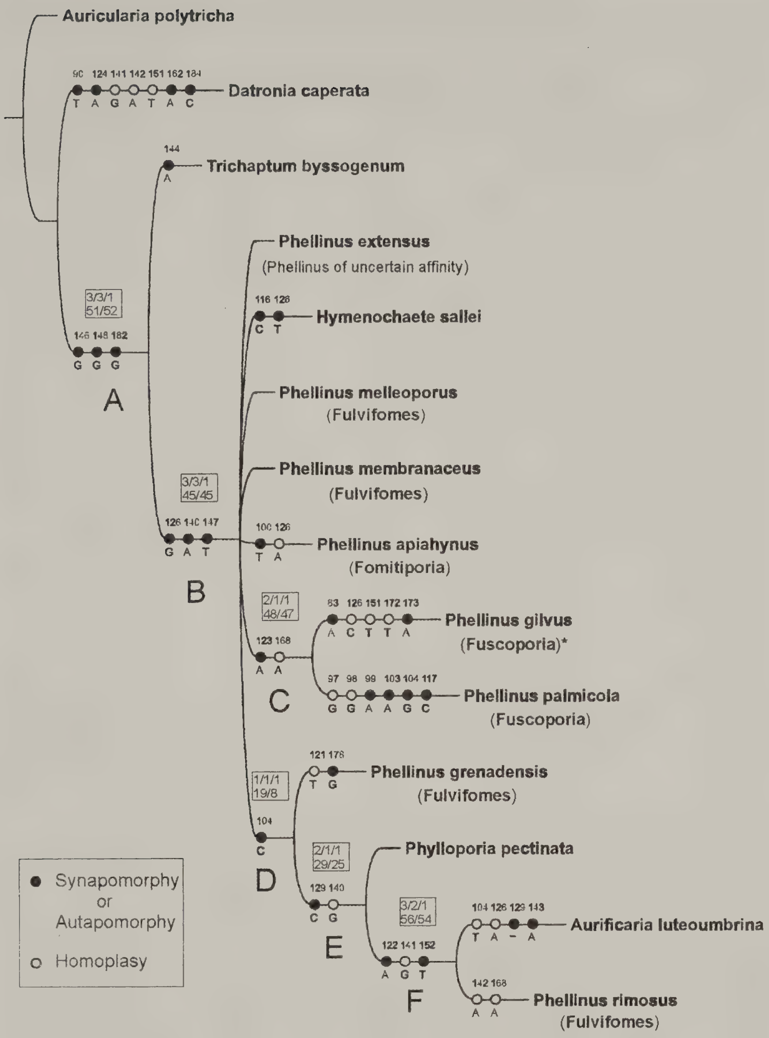
Auricularia polytricha
90 124 141 142 151 162 184
T A G A T A C
Datronia caperata
144
A
Trichaptum byssogenum
Phellinus extensus
(Phellinus of uncertain affinity)
3/3/1
51/52
146 148 182
G G G
A
116 128
C T
Hymenochaete sallei
Phellinus melleoporus
(Fulvifomes)
Phellinus membranaceus
(Fulvifomes)
3/3/1
45/45
126 140 147
G A T
B
100 126
T A
Phellinus apiahynus
(Fomitiporia)
2/1/1
48/47
83 126 151 172 173
A C T T A
Phellinus gilvus
(Fuscoporia)*
123 168
A A
C
97 98 99 103 104 117
G G A A G C
Phellinus palmicola
(Fuscoporia)
121 178
T G
Phellinus grenadensis
(Fulvifomes)
1/1/1
19/8
104
C
D
Phylloporia pectinata
2/1/1
29/25
129 140
C G
E
3/2/1
56/54
104 126 129 143
T A - A
Aurificaria luteoumbrina
122 141 152
A G T
F
142 168
A A
Phellinus rimosus
(Fulvifomes)
● Synapomorphy or Autapomorphy
○ Homoplasy

Fig. 1: Strict consensus tree

Obs1: Only the apomorphies from unambiguous optimization of characters are exhibited.
Obs2: The numbers inside the boxes are clade robustness indicators (Table 4).
Obs3: The numbers above the circles are character numbers (nucleotide sites).
Obs4: The letters below the circles are character states.

* Phellinus gilvus = Fuscoporia (Wagner and Fischer, 2001), = Phellinus s. str. (Fiasson and Niemelä, 1984) (see text for explanation)

Table 2: Number of evolutionary steps, consistence index (CI), retention index (RI), and rescaled consistency index (RC) for each variable character in the strict consensus tree

Character[a] (nucleotide site)	No. of evolutionary steps	Consistency index (CI)	Retention index (RI[b])	Rescaled consistency index (RC[b])
Site 83	*2*	*1.00*	-	-
Site 89	*1*	*1.00*	-	-
Site 90	*1*	*1.00*	-	-
Site 97	3	0.66	0.00	0.00
Site 98	3	0.66	0.00	0.00
Site 99	*1*	*1.00*	-	-
Site 100	*1*	*1.00*	-	-
Site 103	*1*	*1.00*	-	-
Site 104	3	0.66	0.50	0.33
Site 116	*1*	*1.00*	-	-
Site 117	*1*	*1.00*	-	-
Site 118	*1*	*1.00*	-	-
Site 119	*1*	*1.00*	-	-
Site 121	2	0.50	0.00	0.00
Site 122	3	0.66	0.50	0.33
Site 123	1	1.00	1.00	1.00
Site 124	*1*	*1.00*	-	-
Site 125	2	0.50	0.00	0.00
Site 126	6	0.50	0.25	0.12
Site 127	*1*	*1.00*	-	-
Site 129	2	1.00	1.00	1.00
Site 140	2	0.50	0.80	0.40
Site 141	2	0.50	0.50	0.25
Site 142	2	0.50	0.00	0.00
Site 143	*1*	*1.00*	-	-
Site 144	*2*	*1.00*	-	-
Site 145	*1*	*1.00*	-	-
Site 146	1	1.00	1.00	1.00
Site 147	1	1.00	1.00	1.00
Site 148	1	1.00	1.00	1.00
Site 151	2	0.50	0.00	0.00
Site 152	1	1.00	1.00	1.00
Site 161	*1*	*1.00*	-	-
Site 162	*1*	*1.00*	-	-
Site 168	4	0.25	0.25	0.06
Site 171	*1*	*1.00*	-	-
Site 172	2	0.50	0.00	0.00
Site 173	*1*	*1.00*	-	-
Site 178	*1*	*1.00*	-	-
Site 181	*2*	*1.00*	-	-
Site 182	1	1.00	1.00	1.00
Site 183	*1*	*1.00*	-	-
Site 184	*1*	*1.00*	-	-
Site 186	*1*	*1.00*	-	-
Site 189	*1*	*1.00*	-	-

[a] Only the variable characters (parsimony informative or not) are listed. The parsimony non-informative characters are in italics. [b] In autapomorphic characters the values of retention and

rescaled consistency indices are a mathematical indetermination (0/0) and are represented by a hyphen (-).

Table 3: List of synapomorphies based in unambiguous optimization

Branch	Character	Type of change	Change
basal node → A	Site 146		indel → G
	Site 148		indel → G
	Site 182	transversion	T → G
A → B	Site 126	transition	A → G
	Site 140	transition	G → A
	Site 147		indel → T
B → C	Site 123	transition	G → A
B → D	Site 104	transition	T → C
D → E	Site 129	transition	T → C
E → F	Site 122	transition	G → A
	Site 152	transition	C → T

Table 4: Clade robustness indicators

Clade	No. of shared apomorphies[a]	No. of synapomorphies[b]	Decay index	Bootstrap[c] (%)	Jackknife[c] (%)
A	3	3	1	51	52
B	3	3	1	45	45
C	2	1	1	48	47
D	1	1	1	19	8
E	2	1	1	39	25
F	3	2	1	56	54

[a] Hypotheses of primary homology (apparent synapomorphies)

[b] Apparent synapomorphies that passed in congruence test (hypotheses of secondary homology for the level of generality initially proposed)

[c] Heuristic search with 1000 iterations.

The close phylogenetic relationship between *Phylloporia pectinata* and *Aurificaria luteoumbrina* was expected, for not only both taxa possess an intermediary dimitic hyphal system according to Pegler's classification (Pegler, 1995), but it is also in conformity with the molecular phylogenetic analysis of Wagner and Ryvarden (2002), whose authors point out that *Phylloporia* and *Fulvifomes* are closely related. The same is true for the relationship between *Phellinus rimosus* and *Phellinus grenadensis* since both are part of this same species complex: *Phellinus rimosus* (*Fulvifomes* Murr.). Nevertheless, the fact of *Phellinus rimosus* being phylogenetically closer to *Aurificaria luteoumbrina* than any another species of *Phellinus rimosus* complex was totally unexpected. In fact, *Phellinus rimosus* has an eudimitic hyphal system, but intermediary dimitic-like skeletal hyphae can be found in the context of this species, and they are usually described as "secondary generative hyphae" (Larsen and Cobb-Poule, 1990). The less inclusive clades E ((*Aurificaria luteoumbrina, Phellinus rimosus*) *Phylloporia pectinata*) and F (*Aurificaria luteoumbrina, Phellinus rimosus*) were sustained by 1 and 2 synapomorphies, respectively (Table 3), both presenting a decay index of 1, bootstrap values of 39% and 53%, and jackknife values of 25% and 54% respectively (Table 4).

With the exception of clades A and F, respectively placed in the base and in one of the apexes of the trees, all the other clades exhibit bootstrap and jackknife values below 50%, indicating that most of the clades, according to resampling procedures, are not well supported.

Clade Support Indexes

The low bootstrap/jackknife values could be due to the inadequacy of selected gene fragment for the divergence level of studied taxa. The D3 divergent domain, however, was previously used, and with success, to investigate phylogenetic relationships in *Coprinus* (Agaricales, Homobasidiomycetes) with terminal taxa in taxonomic levels similar to those worked in the current study (Hopple and Vilgalys, 1999). The variation of pairwise sequence divergence (0-28,8%) found by Hopple and Vilgalys (1999) was very similar to those found in our work (0-29,6%, data not shown). Furthermore, most of D3 divergent domain sites in the studied taxa have small number of changes, which configures a good condition for phylogenetic inference. Therefore, apparently, there is not any strong evidence that the selected gene fragment was inadequate for the examined divergence level.

Thus, a randomization test was performed for testing if there is a statistically significant positive correlation between apomorphy number and resampling proportions (bootstrap and jackknife values). Randomization tests are more appropriate to test hypotheses because the probability $P(\lambda^{o} \geq \lambda)$ is generated from the observed data, and it is not obtained in tables with the assumption that the distribution of λ is in conformity with a specific type of theoretical distribution that is not always valid or possible of being demonstrated (Pillar and Orlóci, 1996). The randomization test was conducted in MULTIV (Pillar, 1998), using the following parameters: (i) logarithmic scalar transformation of the data, (ii) correlation between variables (resemblance measure) as the test criterion (λ), (iii) 1000 iterations, (iv) significance level of 5% (α = 0,05). The number of iterations and significance level were selected according to Crowley (1992).

Statistically significant positive correlations for apomorphy number and bootstrap values (P = 0,024) as well as for apomorphy number and jackknife (P = 0,038) were encountered. Thus, as there is a statistically significant positive correlation between branch support values by resampling techniques and number of evolutionary steps in these same branches, the low branch support values (bootstrap/jackknife) should be related to the topology of the tree (short internal branches), so that they are linked to taxa and not to characters. Hence, the presence of clades separated by short internal branches, which have low number of changes or evolutionary steps in this molecular phylogeny of Hymenochaetales, could be a result of a high diversification rate of this group of Homobasidiomycetes. Cladogenetic events separated by short periods of time could be the explanation for the presence of these short branches. This same hypothesis was also suggested by Mardulyn and Whitfield (1999) when studying the same gene (rDNA 28S, complete sequence) for Microgastrinae (Hymenoptera, Metazoa).

There is, at least, some evidences that corroborate this hypothesis: eight of the fourteen studied taxa are species of *Phellinus s. lat.*, which is the most diverse polypore genus with a high specific richness, mainly in tropical regions.

This genus embraces several species complexes, characterized by the relative homogeneity of their component species, which are morphologically similar and of difficult differentiation (Larsen-Cobb-Poule, 1990; Ryvarden, 1991, 1993). This fact, allied to the low observed genetic divergence among the different species of *Phellinus* in a gene fragment with very low level of saturation, suggest a recent diversification.

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A NEW SPECIES OF CETRELIOPSIS (ASCOMYCOTINA, PARMELIACEAE) FROM THAILAND

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ABSTRACT: *Cetreliopsis thailandica* is reported as new to science. The secondary chemistry of this species has been determined and that of related taxa clarified.

KEY WORDS: *Cetreliopsis thailandica*, *Cetreliopsis rhytidocarpa*, *Cetreliopsis rhytidocarpa* subsp. *langtangi*, *Cetreliopsis papuae*, quaesitic acid, conquaesitic acid

Species and genera of the cetrarioid lichens in the family Parmeliaceae are poorly known in continental Southeast Asia (Lai 1992; Lai & Qian 1995). To date *Nephromopsis laii* (Thell & Randl.) Saag & Thell, *N. nephromoides* (Nyl.) Ahti & Randl. (Randlane & Saag 1998), *Cetreliopsis asahinae* (M. Satô) Randl. & Thell (Randlane *et al.* 1995) and *Platismatia erosa* W.L. Culb. & C.F. Culb. (Culberson & Culberson 1968) have been reported from Vietnam, while *Cetrelia braunsiana* (Müll. Arg.) W.L. Culb. & C.F. Culb., *C. japonica* (Zahlbr.) W.L. Culb. & C.F. Culb., *C. nuda* (Hue) W.L. Culb. & C.F. Culb., *Nephromopsis pallescens* (Schaer.) Y.S. Park var. *pallescens* and *N. ornata* (Müll. Arg.) Hue (Wolseley & Aguirre-Hudson 1995) are known from Thailand.

The Asiatic genus *Cetreliopsis* M.J. Lai is characterized by the presence of pseudocyphellae on both lower and upper surfaces of the thallus (Lai 1980; Randlane *et al.* 1995). Superficially this genus resembles the well-known *Cetrelia,* but is clearly distinguished from the latter by morphological, anatomical and chemical differences (Randlane *et al.* 1995). More particularly, whereas *Cetrelia* contains cortical atranorin and chloroatranorin and medullary orcinol depsides, *Cetreliopsis* contains usnic acid in the upper cortex and β-orcinol depsidones in the medulla. Recently, a collection from northern Thailand has been identified as a new species of *Cetreliopsis* which is described here. Chemical constituents were identified by thin layer chromatography (Culberson 1972; Culberson *et al.* 1981; Culberson & Johnson 1982; Elix & Ernst-Russell 1993), high performance liquid chromatography (Feige *et al.* 1993; Elix & Wardlaw 2000) and comparison with authentic samples.

THE NEW SPECIES

Cetreliopsis thailandica Elix & M.J. Lai, sp. nov. Fig. 1

Thallus ut in *Cetreliopsis rhytidocarpa* subsp. *langtangi* sed superfice superiore testaceus, marginibus lobis crispus et lobulatis et acidum quaesiticum majoribus et acidum conquaesiticum continente differt.

Type. THAILAND. Chiang Mai Province: Doi Suthep, Sankuu, 1400 m, on tree trunk, *Kwanruan Papong RU-4147A*, 16 Jan. 1995 (holotype-RAMK; isotype-CANB).

Thallus corticolous, foliose, loosely adnate, coriaceous, to 9 cm wide. *Lobes* irregular, weakly imbricate, 5-15 mm wide, margins crisped and lobulate, lobules rotund, 1-2 mm wide, lobe apices rotund, cilia absent. *Upper surface* pale yellow-brown, flat, smooth, shiny, rarely ridged, pseudocyphellate, pseudocyphellae laminal, puctiform, white, rounded, concave, soredia and isidia absent. *Lower surface* ivory to yellow-brown, black in centre, rugose and ridged, pseudocyphellate, pseudocyphellae punctiform on ridges, white, rounded, concave. *Apothecia* marginal, vestigial. *Pycnidia* common, along the lobe margins and rarely on laminal ridges, on markedly elongated projections (to 1 mm high) which become blackened towards the apices. *Conidia* weakly bifusiform, 4 x 1 µm.

Chemistry. Cortex K-, medulla K+ yellow-brown, C-, P+ orange-red; containing usnic acid in the cortex (trace or absent), quaesitic acid (major), conquaesitic acid (minor), fumarprotocetraric acid (minor), protocetraric acid (trace), salazinic acid (trace), 9α-*O*-methylsalazinic acid (trace), protolichesterinic acid (minor/trace) and unknown fatty acid (minor/trace) in the medulla.

Cetreliopsis thailandica resembles *Cetreliopsis rhytidocarpa* subsp. *langtangi*, as these two taxa have similarly loosely adnate thalli with a pale lower surface which only becomes black in the centre, and punctiform pseudocyphellae on both upper and lower surfaces. However, *C. thailandica* differs in the colour of the upper surface (pale yellow-brown cf. yellow-green to green), in having lobes with markedly crisped, lobulate margins (cf. margins that are plane to undulate), in having white, concave, rotund pseudocyphellae (pseudocyphellae form convex, rounded or irregular patches with a black rim in *C. rhytidocarpa* subsp. *langtangi*) and having dense marginal pycnidia on markedly elongated projections (pycnidia are only weakly emergent in *C. rhytidocarpa* subsp. *langtangi*). These two taxa also differ in their secondary chemistry, quaesitic acid being the major metabolite in *C. thailandica*, whereas fumarprotocetraric acid in the major compound present in *C. rhytidocarpa* subsp. *langtangi*. At present this new species is only known from the type collection.

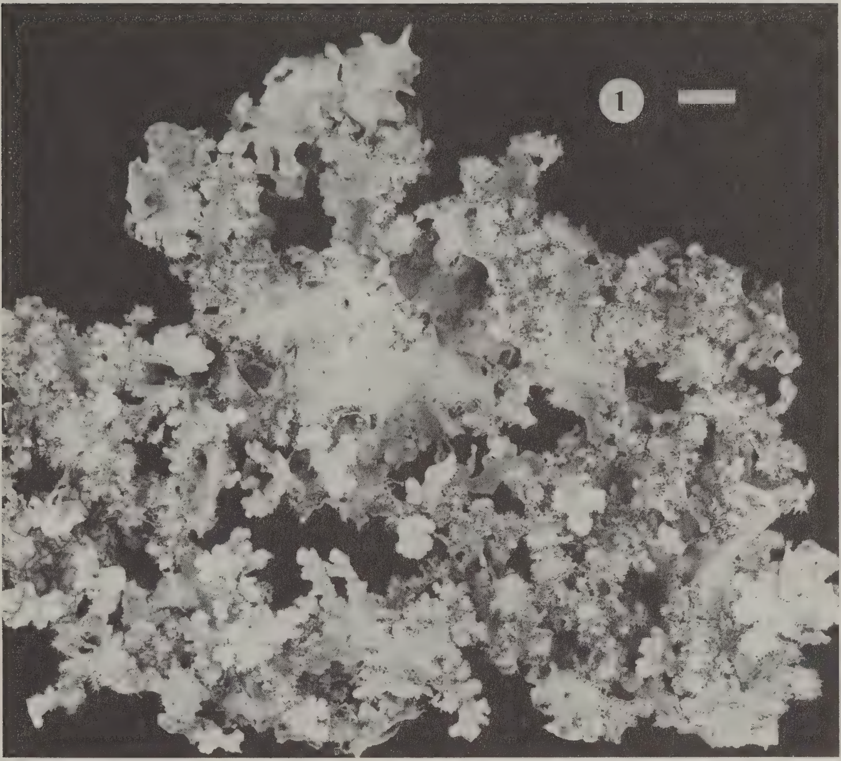


Figure 1. *Cetreliopsis thailandica* (isotype in CANB). Scale bar = 5 mm.

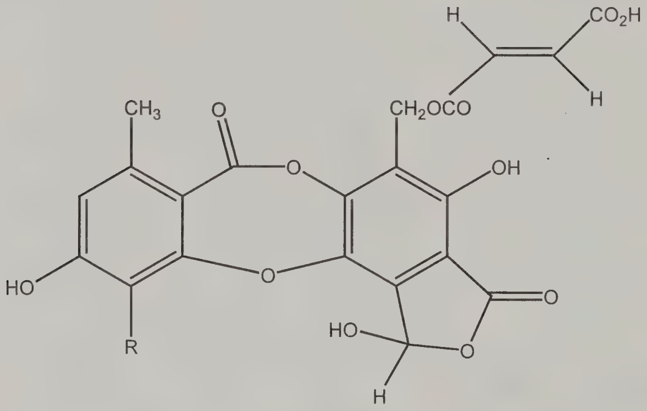
In view of these chemical differences, the medullary chemistry of several other species *Cetreliopsis* was investigated and the results are reported below.

Cetreliopsis rhytidocarpa (Mont. & Bosch) M.J. Lai subsp. ***rhytidocarpa***, *Quart. J. Taiwan Mus.* **33**: 218. 1980.

Chemical constituents: usnic acid in the cortex (trace); fumarprotocetraric acid (major), quaesitic acid (minor), protocetraric acid (minor), 9α-*O*-methylsalazinic acid (trace), salazinic acid (trace), succinprotocetraric acid (trace), protolichesterinic acid (major) and unknown (minor/trace) in the medulla.

Although containing the same chemosyndrome of β-orcinol depsidones, the chemistry of this species differs from that of *C. thailandica* in the relative proportions of fumarprotocetraric and quaesitic acids and by the absence of conquaesitic acid. Quaesitic acid was referred as the "salazinic-like substance Cph-1" by Randlane *et al.*

al. (1995). The unknown Cph-1, first reported from *Cladonia phyllophora* Hoffm. (Culberson *et al.* 1981), has now been shown to be synonymous with quaesitic acid. Quaesitic acid is, in effect, an analogue of fumarprotocetraric acid. This substance was detected in *Hypotrachyna quaesita* (Kurok.) DePriest & B. Hale (Kurokawa 1988) and the structure subsequently elucidated by Elix & Wardlaw (1999). Thus the structural relationship between protocetraric acid and fumarprotocetraric acid parallels that between quaesitic acid and salazinic acid. Obviously, *H. quaesita* and *Cetreliopsis* species contain an enzyme which can effect the fumaroylation of both protocetraric acid and salazinic acid, the natural precursors of the more highly derived depsidones, fumarprotocetraric acid and quaesitic acid. The structure of quaesitic acid and conquaesitic acid is shown in Fig. 2.



Quaesitic acid, R = CHO

Conquaesitic acid, R = CH_2OH

Figure 2. Structure of quaesitic and conquaesitic acids.

The latter substances exhibited the following chromatographic properties - standard TLC R_F values: quaesitic acid R_F (A) 0.10; R_F (B') 0.15; R_F (C) 0.06; R_F (G) 0.30; conquaesitic acid R_F (A) 0.02; R_F (B') 0.04; R_F (C) 0.01; R_F (G) 0.12. Standard HPLC: quaesitic acid R_T 18.5 min.; R_I 0.19; conquaesitic acid R_T 14.2 min.; R_I 0.03.

Specimens examined

PAPUA NEW GUINEA. Central Province, near Efogi, grid ref. EK 7487, 1700 m, on fallen branch in *Lithocarpus* forest, *P. W. Lambley 1435*, 4 Dec. 1987 (CANB); Milne Bay Province, Bonenau, Mt Mon, grid ref. GK 5909, 2000 m, on branch in *Castanopsis* forest, *P. W. Lambley 732*, 15 Nov. 1986 (CANB). PHILIPPINES. Mindanao, Cotabato Province, Lake Venado, Mt Apo, 7°00'N, 125°16'E, 2200 m, on branch in tropical rainforest, *F. Schumm 6110 & U. Schwartz,* 10 Aug. 1999 (CANB).

Cetreliopsis rhytidocarpa (Mont. & Bosch) M.J. Lai subsp. ***langtangi*** Randl. & Thell, *Cryptog. Bryol. Lichénol.* **16**: 54. 1995.

Chemical constituents: usnic acid in the cortex (trace); fumarprotocetraric acid (major), quaesitic acid (minor), protocetraric acid (minor), 9α-*O*-methylsalazinic acid (trace), salazinic acid (trace), succinprotocetraric acid (trace), protolichesterinic acid (major) and unknown (minor/trace) in the medulla. The chemistry of this subspecies was identical with that of *C. rhytidocarpa* subsp. *rhytidocarpa.*

Specimens examined
NEPAL. Central Himalaya, Langtang area, below Dotsche, 2880 m, on branches in *Quercus semicarpifolia* forest, *G. & S. Miehe 15738b*, 8 Nov. 1986 (GZU-holotype); Langtang area, Upper Tadi Khola, 2880 m, on branches in *Quercus-Tsuga* forest, *G. & S. Miehe 15822a*, 10 Nov. 1986 (GZU).

Cetreliopsis papuae Randl. & Saag, *Cryptog. Bryol. Lichénol.* **16**: 52. 1995.

Chemical constituents: usnic acid in the cortex (trace); fumarprotocetraric acid (major), quaesitic acid (minor), protocetraric acid (minor), 9α-*O*-methylsalazinic acid (trace), salazinic acid (trace), succinprotocetraric acid (trace), protolichesterinic acid (major) and unknown (minor/trace) in the medulla. The chemistry of this species was also identical with that of *C. rhytidocarpa* subsp. *rhytidocarpa.*

Specimens examined
PAPUA NEW GUINEA. Star Mountains, E side of Mt Scorpion, 3600 m, in an open herbfield of *Tetramolopium* and *Astelia*, *G. S. Hope s.n.*, May 1975 (*Lich. Exsicc.* distributed by the University of Colorado Museum, Boulder no. 483 (two isotypes; CANB).

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THE ANAMORPHS OF ERYSIPHE HYLOMECI AND E. URTICAE

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ABSTRACT: The anamorph of *Erysiphe hylomeci* has not yet been recorded and that of *E. urticae* has been insufficiently known. Conidia, conidiophores, hyphae, appressoria, germination of conidia and other characters of taxonomic value are described and illustrated.

Keywords: *Hylomecon*, *Urtica*, powdery mildew, Erysiphaceae

Since the taxonomy of powdery mildew fungi was formerly mainly based on teleomorphic characteristics, many species of this fungal group have been described without adequate information on their corresponding anamorphic states. The taxonomic value of the conidial states has been emphasized by many authors (Zaracovitis, 1965; Boesewinkel, 1980; Shin, 2000) and practically applied for the differentiation of closely related taxa (Boesewinkel, 1979; Shin, 1993; Shin & Zheng, 1998). Various characters found in the conidial states, viz., morphometric data of conidia and conidiophores, presence or absence of fibrosin bodies, position of germ tubes on conidia, position of conidiophores on mother cells, etc., have been used. Nevertheless, descriptions of morphological features of the anamorphs in many powdery mildews are totally absent or poorly known.

In the present paper, the anamorphic characteristics of two *Erysiphe* species, *E. hylomeci* H.D. Shin & Y.J. La and *E. urticae* (Wallr.) Blumer, are described. The identity of the two powdery mildew species and the connections of anamorph and teleomorph could be confirmed by examining conidial states and ascomata from the same colonies. Lactic acid technique (Shin, 1988) was used for restoring shriveled structures of dried materials. Observations and line drawings were made under 400X magnification of a light microscope (Olympus BX 50) with a drawing tube (DA).

Conidial state of *Erysiphe hylomeci* H.D. Shin & Y.J. La Fig. 1

Mycelium amphigenous, but mostly epiphyllous, thinly effused or forming circular to irregular white patches, sometimes conspicuous and showing powdery appearance on the upper surface of leaves growing in the shade; **hyphae** substraight to wavy, 35-75×3.5-7 µm, branching at right or narrow angle, with a septum near the branching point. **Secondary mycelium** absent. **Appressoria** multilobed or nipple-shaped, opposite in pairs or single. **Conidiophores** one or two on a hyphal cell, arising from the upper part of mother cells, position mostly central, 74-98×8-11 µm, producing conidia singly, followed by 2-3 cells, foot-cells 22-40 µm long, slightly to moderately flexuous, with a basal septum at the branching point of the mycelium. **Conidia** oval to cylindrical-oval, 28-40(-48)×15-18 µm (l/w = 1.6-2.6), without conspicuous fibrosin bodies, producing subterminal germ tubes.

Materials examined: On *Hylomecon vernale* Maxim, SMK 18234 (19 VII 2001, Pochon, Korea, leg. & det. H. D. Shin), 18293 (24 VIII 2001, ibid), 18512 (27 IX 2001, ibid).

Note: The conidial state of the present species has not been recorded since it was described on the basis of teleomorphic features (Shin, 2000). Though the host plant is common in Korea, the powdery mildew on this plant is rather uncommon. The present author had collected ascomata of this species several times by chance, but most of the collections did not contain well-developed conidial states. In 2001, the conidial state of this fungus was collected and examined. The anamorphic characteristics of the present species are closely allied to *Erysiphe cruciferarum* Opiz ex L. Junell, but different from it by having conidiophores with flexuous foot-cells.

Conidial state of *Erysiphe urticae* (Wallr.) S. Blumer Fig. 2

Mycelium amphigenous, but mostly epiphyllous, conspicuous, forming dense white patches, sometimes thinly effused on the lower leaf surface; **hyphae** substraight to wavy, 28-75×3.5-6 µm, branching at right or narrow angle, with a septum near the branching point. **Secondary mycelium** absent. **Appressoria** multilobed to moderately lobed, opposite in pairs or single. **Conidiophores** one or two or occasionally three on a hyphal cell, arising from the upper part of mother cells, position mostly non-central, 64-164×5-8 µm, straight at the base of the foot-cells, producing conidia singly, followed by 2-3(-4) cells, foot-cells long, with a basal septum displaced up to 10 µm away from the branching point of the mycelium. **Conidia** oval to cylindrical-oval, 24-36(-40)×11-15 µm (l/w = 1.8-3.2), without conspicuous fibrosin bodies, germ tubes subterminal.

Materials examined: On *Urtica angustifolia* Fisch., HMAS 73584 (2 VIII 1995, Beijing, China, leg. & det. Y.C. Su); on *Urtica dioica* L., material deposited in O (Univ. of Oslo) without accession number (ex herb. Univ. Helsingiensis; 21 IX 1960, Aabo, Finland, leg. & det. Laila & H. Roivainen).

Note: Teleomorphic features of the two collections cited were in good accordance with *E. urticae* described by Braun (1987) and Zheng & Yu (1987). Brief descriptions of the conidia were provided by Braun (l.c.) and Zheng & Yu (l.c.), respectively. The conidia observed by the present author were somewhat longer than those of Braun (20-25 x 10-16 µm) but in agreement with those of Zheng & Yu (22.9-38.1 x 10.2-16.3 µm).

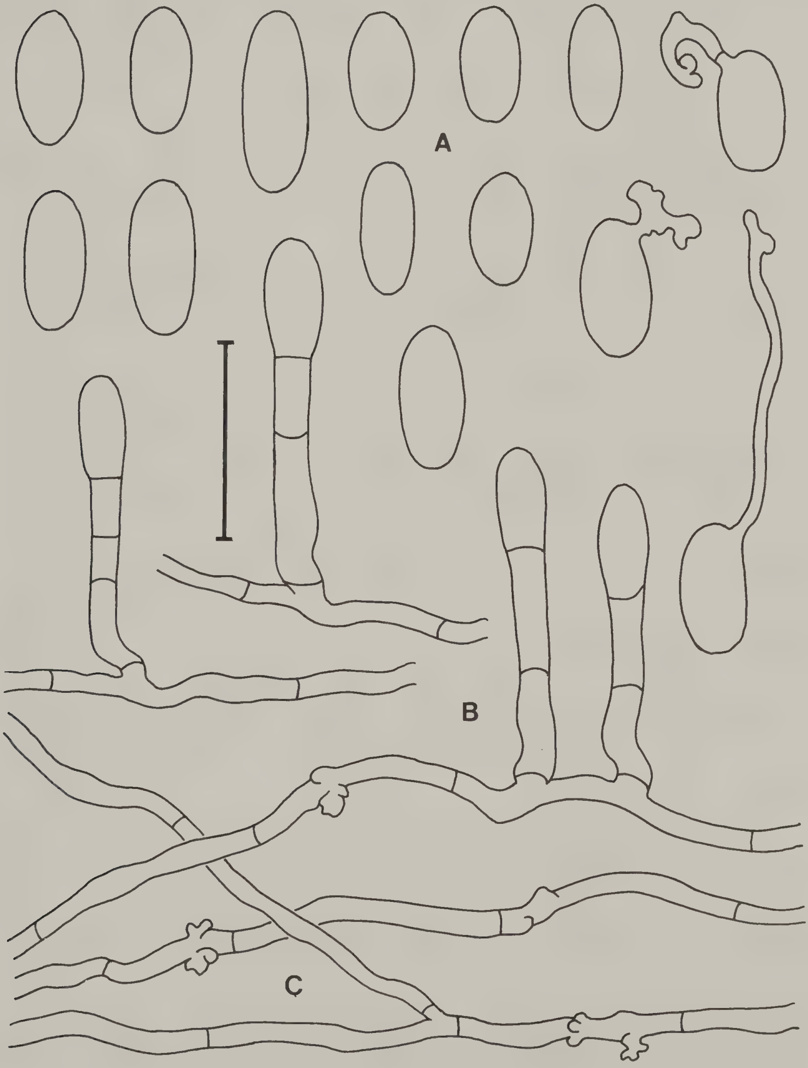

Fig. 1. *Erysiphe hylomeci* H.D. Shin & Y.J. La. **A**: conidia. **B**: conidiophores. **C**: mycelium with appressoria. (bar = 50 µm).

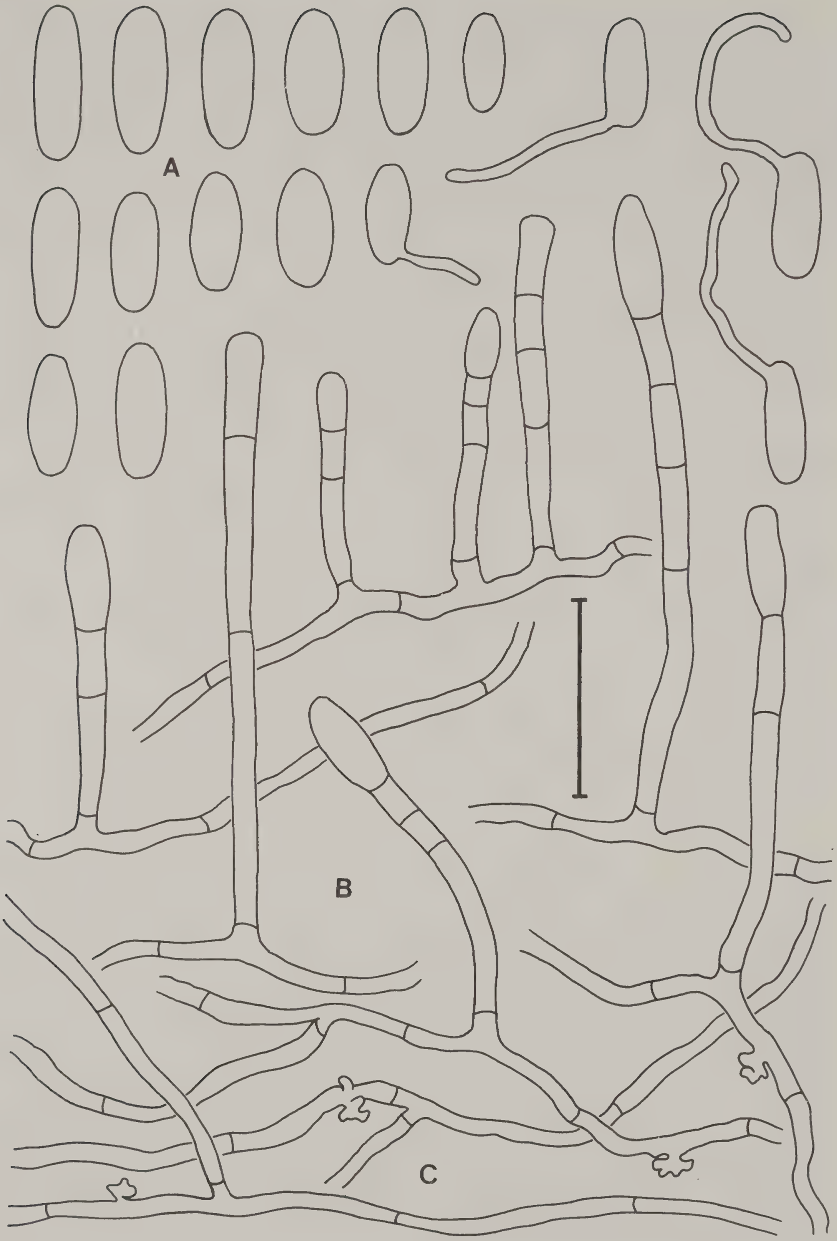

Fig. 2. *Erysiphe urticae* (Wallr.) S. Blumer. **A**: conidia. **B**: conidiophores. **C**: mycelium with appressoria. (bar = 50 μm).

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ZYGORHYNCHUS MULTIPLEX, A NEW SPECIES ISOLATED FROM PADDY SOIL*

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ABSTRACT

A new species of the genus *Zygorhynchus*, *Z. multiplex*, isolated from paddy soil of the Guangxi Province of China, is described. The fungus is characterized by its complicated sporophore construction, as well as by its shape and dimension of columellae. A key to all taxa of the genus, with their related synonyms attached, is provided.

KEY WORDS: *Zygorhynchus*, Mucoraceae, Mucorales, Zygomycetes, taxonomy.

摘要

本文报道了分离自我国广西省南宁市沙井乡水稻田土壤中的一个接霉属新种，复孢枝接霉 (*Zygorhynchus multiplex*)。其形态特征为孢子枝构造复杂，具有明显的主轴，主轴顶生一个孢子囊，顶生孢子囊有时可以为一个不育的刺所替代，下面有许多侧生分枝，侧生分枝可以完全由孢囊梗组成，也可以完全由接合孢子梗组成，更可以由孢囊梗和接合孢子梗混合组成；初生分枝往往 3－5 轮状分枝，也可以是单生、成双或单轴状分枝，更可以是由上述几种分枝方式混合连续分枝数次。这样复杂的孢子枝构造在同属的已知种中从未见有报道

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。再者，在全部已知种中，大多数种的囊轴都以扁形为主，只有日本接霉 (*Z. japonicus*)一种的囊轴以梨形为主，较少球形，新种的囊轴同样没有扁形的，但较多样化，以卵形的最多，其次是近球形或球形，少数情况下还可以是梨形或椭圆形；此外，新种的囊轴高度达 84 微米，其他已知种则至多达到 40 微米。文章除对新种进行描述外，还讨论了接霉属与其近缘属毛霉属 (*Mucor*) 之间的关系，对所确认的包括新种在内的全世界接霉属种类提供了分种检索表，并在相关的种下附有异名名单，即对接霉属的 24 个已报道名称中，确认其中的 7 个种，有 14 个名称被作为异名处理，其余 3 个种被排除出接霉属之外。

Zygorhynchus Vuill. (Vuillemin, 1903) is a genus closely related to *Mucor* Fresen. (Fresenius, 1850). Reasons for considering the two genera distinct from each other have been discussed by both Hesseltine *et. al.* (1959) and Schipper (1986) in their monographic studies on *Zygorhynchus*. According to Hesseltine *et al.* (1959), these include: (1) all species of *Zygorhynchus* are homothallic, while species of *Mucor* are typically heterothallic; (2) the two suspensors supporting a zygosporangium are of unequal size and shape in *Zygorhynchus* and of more or less equal size and shape in *Mucor*; (3) zygospores are produced throughout the aerial portion of the colony in *Zygorhynchus* but are usually borne on special zygophores near the surface of the substrate in *Mucor*. Schipper (1986) further added that, in all species of *Zygorhynchus,* the two gametangia which copulate and lead to the formation of a zygosporangium usually occur on the same aerial hypha, although a very few species like *Z. exponens* Burgeff and *Z. japonicus* Komin., have both the *Zygorhynchus*-type and *Mucor*-type of gametangial position; in species of *Mucor*, either heterothallic or homothallic, the two gametangia always originate from different hyphae and never from the same hypha. Results of the molecular studies on mucoralean fungi made by O'Donnell *et al.* (2001) also indicate that these two genera are phylogenetically distinct.

Among the 24 taxa hitherto published in *Zygorhynchus* (Funindex: Anonymous, 2002), Hesseltine *et al.* (1959) recognized 6 species and 1 variety, namely, *Z. heterogamus* (Vuill.) Vuill. (Vuillemin, 1903, type species of the genus), *Z. moelleri* Vuill. (Vuillemin, 1903), *Z. japonicus* Komin. (Kominami, 1914), *Z. exponens* Burgeff (Burgeff, 1924) var. *exponens*, *Z. macrocarpus* Y. Ling (Ling, 1930), *Z. californiensis* Hesselt. *et al.* (Hesseltine *et al.*, 1959), and *Z. exponens* var. *smithii* Hesselt. *et al.* (Hesseltine *et al.*, 1959). The following 12 names were treated as synonyms of the related species: *Z. vuilleminii*

Namysl. (Namyslowski, 1910), *Z. vuilleminii* race *agamus* Namysl. (Namyslowski, 1911), *Z. dangeardii* Moreau (Moreau, 1912), *Z. bernardii* Moreau (Moreau, 1913), *Z. circinelloides* Pišpek (Pišpek, 1929), *Z. griseocinereus* Pišpek (Pišpek, 1929), *Z. phosphoreus* Pišpek (Pišpek, 1929), *Z. polygonosporus* Pišpek (Pišpek, 1929), *Z. viridis* Pišpek (Pišpek, 1929), *Z. vuilleminii* var. *dangeardii* (Moreau) Zycha (Zycha, 1935), *Z. vuilleminii* var. *albus* Christenb. (Christenberry, 1940), and *Z. verruculosus* Tehon (Tehon, 1943). One name, *Z. hennebergii* Naumov (1935, see Naumov, 1939), was considered to be doubtful. Since then, a new species, *Z. psychrophilus* Schipper & Hintikka (Schipper & Hintikka, 1969) was described, and three of the *Mucor* species were transferred to *Zygorhynchus* by von Arx (1982) with the combinations of *Z. indicus* (Lendn.) Arx [basionym: *M. indicus* Lendn. (Lendner, 1930)], *Z. bacilliformis* (Hesselt.) Arx [basionym: *M. bacilliformis* Hesselt. (Hesseltine, 1954)], and *Z. amphibiorum* (Schipper) Arx [basionym: *M. amphibiorum* Schipper (Schipper, 1978)]. Several years later, ex-type cultures of *Zygorhynchus* were restudied by Schipper (1986). Five of the seven taxa accepted by Hesseltine *et al.* (1959), i.e. *Z. heterogamus, Z. moelleri, Z. japonicus, Z. exponens*, and *Z. californiensis*, were confirmed; whilst the other two, *Z. exponens* var. *smithii* and *Z. macrocarpus*, were synonymized with *Z. exponens* and *Z. heterogamous,* respectively. Together with *Z. psychrophilus*, six species in total were admitted in *Zygorhynchus*. The three species transferred from *Mucor* were excluded. Assignment of the other taxa as synonyms to the correct names was omitted. Schipper's (1986) classification of this genus is adopted in the present study.

An old culture preserved in our laboratory was studied recently and identified as a new member of *Zygorhynchus, Z. multiplex*. The species epithet refers to the complexity of sporangiophore construction. This fungus was isolated from a soil sample collected from a paddy field in Nanning, Guangxi Province, south-western part of China, by using soil-plate method (Warcup, 1950) and PDA as isolation medium and incubated at 24℃ for 3-5 days. Morphological studies were based on fructifications grown on modified SMA (modified Synthetic *Mucor* Agar which contains dextrose 20 g, asparagine 2 g, KH_2PO_4 0.5 g, $MgSO_4 \cdot 7H_2O$ 0.25 g, thiamine chloride 0.5 mg, agar 20 g in 1000 ml distilled water) and PDA, both at 24℃ over a period of 4 – 10 days. Growth temperature was tested at different temperatures of 0 – 32℃ for 4 – 7 days with 2 repetitions.

Zygorhynchus multiplex R. Y. Zheng sp. nov. (Figs.1 & 2; Pl. I)

Coloniae caespitem sparsum formantes, 1 cm altae, temp. 15 - 25℃ in SMA et PDA bene crescentes, Petri patellas 4 - 5 diebus temp. 24℃ implentes, incremento seu infra temp. 10℃ seu super temp. 29℃ cessato, primum albae, cito zygosporis formatis grisescentes, reverso nigellae. *Odor* mucidus. *Hyphae* ramosae, juvenes eseptatae, vestustae septatae, in mycelio aeriio 5.5 - 18.5 μm, in mycelio submerso 9 - 18.5 (- 25) μm latae, cellulis nonnumquam ad 27 - 110 × 11 - 30 μm inflatis. *Stolones* absentes. *Rhizoidea* absentia. *Sporangiophora* ex hyphis aeriis vel submersis enata, axibus (17.5 -) 23.5 - 33 μm, ramis 6 - 23.5 μm latis, pro magna parte diametro aequalia, sed in parte suprema attenuata, interdum ad locos inflata, hyalina, brunneolis ad dilute brunneos, laevigata ad verrucosa, 4 typos principales praebentia: (1) sporangiophora ramosa vel simplicia, sporangium solum ferentia; (2) sporangiophora sporangium terminale et ramos laterales formantia qui ambo sporangia et zygosporangia proferunt; (3) sporangiophora sporangium terminale et numerosos ramos laterales formantia qui zygosporangia solum proferung; (4) sporangium terminale spina sterili substituta, ramis lateralibus solum zygosporangia ferentibus. In omni typo rami primarii solitarii, bini, monopodiales, vel 3 - 5-verticillati, praeterea repetite monopodialiter vel sympodialiter ramosi, quoque ramo in sporangium, zygosporangium vel spinam plus minusve longam exeunte. *Sporangia* terminalia in axibus primariis vel ramis, globosa ad depresso-globosa, 47 - 94 (- 106) μm diam., non apophysata, frangentia vel tabida, juvenilia luteola ad brunneola, matura fuscescentia. *Columellae* ovoideae vel subglobosae vel globosae, interdum piriformes, raro ellipsoideae, magnam partem sporangii replentes, (28 -) 59 - 84 × (25 -) 47 - 73 μm vel 56 - 83 μm diam., subhyalinae vel dilute brunneae, laevigatae, collari distincto. *Sporangiosporae* praecipue breviter ovoideae vel subglobosae vel globosae, interdum ellipsoideae vel oblongo-ellipsoideae, raro subtriangulares, allantoideae vel irregulariter conformatae, 2.5 - 5.5 × 2 - 5 μm vel 2 - 5.5 μm diam., hyalinae, griseolae in massa, laevigatae, frequenter uni-guttatae ad multi-guttatas. *Chlamydosporae* absentes.

Zygosporangia per totam coloniam sed maxime copiosa super substratum, globosa ad leniter compressa inter duos suspensores, 37 - 83 μm diam., matura fusca ad atra, protuberantiis obtusis vel tuberculiformibus obtecta. *Zygosporae* late ovoideae vel subglobosae, 32 - 78 × 27.5 - 71 μm vel 32 - 69 μm diam., hyalinae, tenuitunicatae, sublaevigatae vel crenatae, dein tuberculatae, juveniles 1 - 14 globulos continentes, quae postea in unum globulum magnum confluent. *Suspensores* inaequales, minores non inflati, recti, perbreves, 2.5 - 13 μm alti et 9 - 16 μm lati, hyalini, laeves, plerumque eseptati; majores inclinati et recurvi, 55 - 250 μm longi, sursum leniter dilatati et abrupte in formam globosam vel ovoideam inflati, 27.5 - 41 μm diam. in parte inflata, 8.5 - 14 μm ad basim, dilute brunnei ad aurantio-brunneos, frequenter incrustati. Species *homothallica.*

HOLOTYPUS: HMAS 84256-1 - 7, cultura exsiccata ex AS 3.5865, isolata e terra agri *Oryzae*, lecta in Nanning, Provincia Guangxi, a Yu Ming-qiu, 19 Oct. 1985, in Herbario Mycologico Instituti Microbiologici Academiae Sinicae (HMAS) conservatus. Cultura viva (AS 3.5865, = Z-18) in AS Collectione Culturae Instituti Microbiologici Academiae Sinicae deposita.

Colonies with sparse turf reaching 1 cm in height, growing well at 15 - 25℃ on SMA and PDA, filling the Petri dish in 4 - 5 days at 24℃, no growth occurring at or below 10℃ and at or above 29℃, at first white, soon becoming gray to slate gray with the formation of numerous zygospores, reverse blackish. Odor mouldy. *Hyphae* branching, nonseptate when young, septate in age, aerial hyphae 5.5 - 8.5 μm, submerged hyphae 9 - 18.5 (- 25) μm wide, with swollen cells reaching 27 - 110 ×11 - 30 μm. *Stolons* and *rhizoids* absent. *Sporangiophores* arising from aerial mycelia and

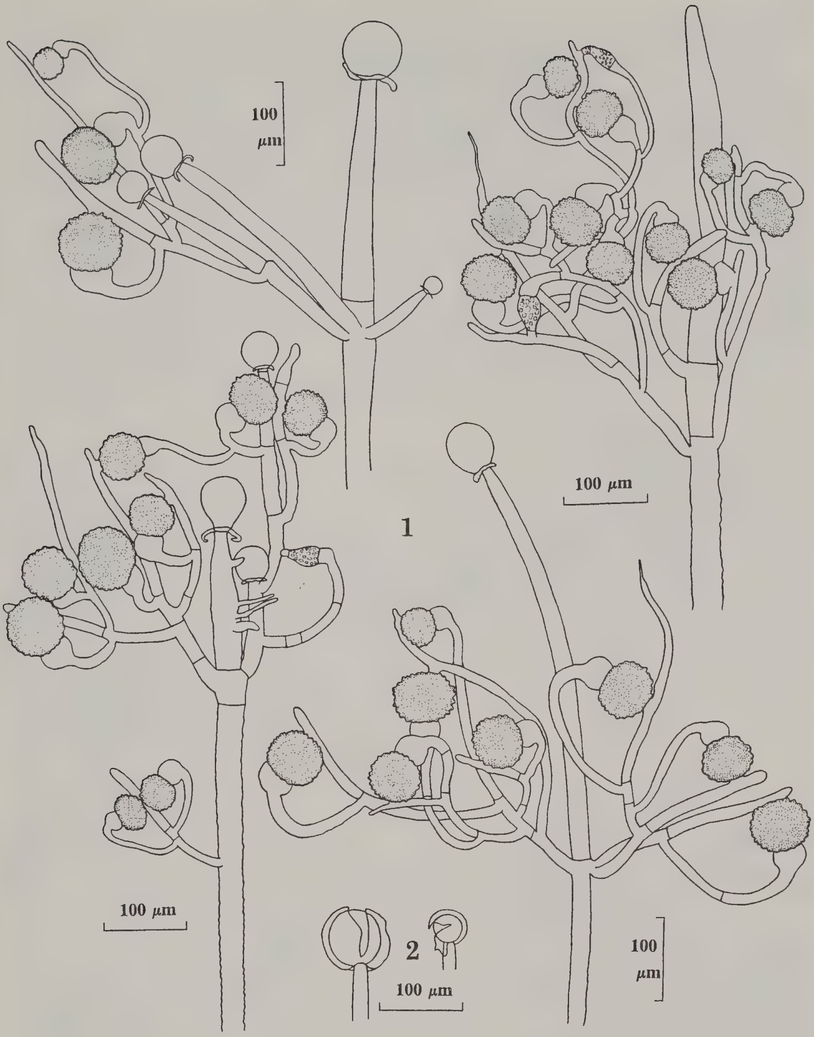

Fig. 1. *Zygorhynchus multiplex*. 1. Terminal portions of sporangiophores showing various kinds of construction. Upper left: sporangiophore with a terminal sporangium and verticillate branches below, note that zygophores are formed from one of the primary branches. Lower left: sporangiophore with a terminal sporangium and monopodially branched sporangiophores and zygophores below. Upper right: sporangiophore with a terminal sterile spine and monopodially branched zygophores below. Lower right: sporangiophore with a terminal sporangium and verticillately branched zygophores below. 2. Two broken and emptied sporangia, note the large columellae in relation to the sporangia.

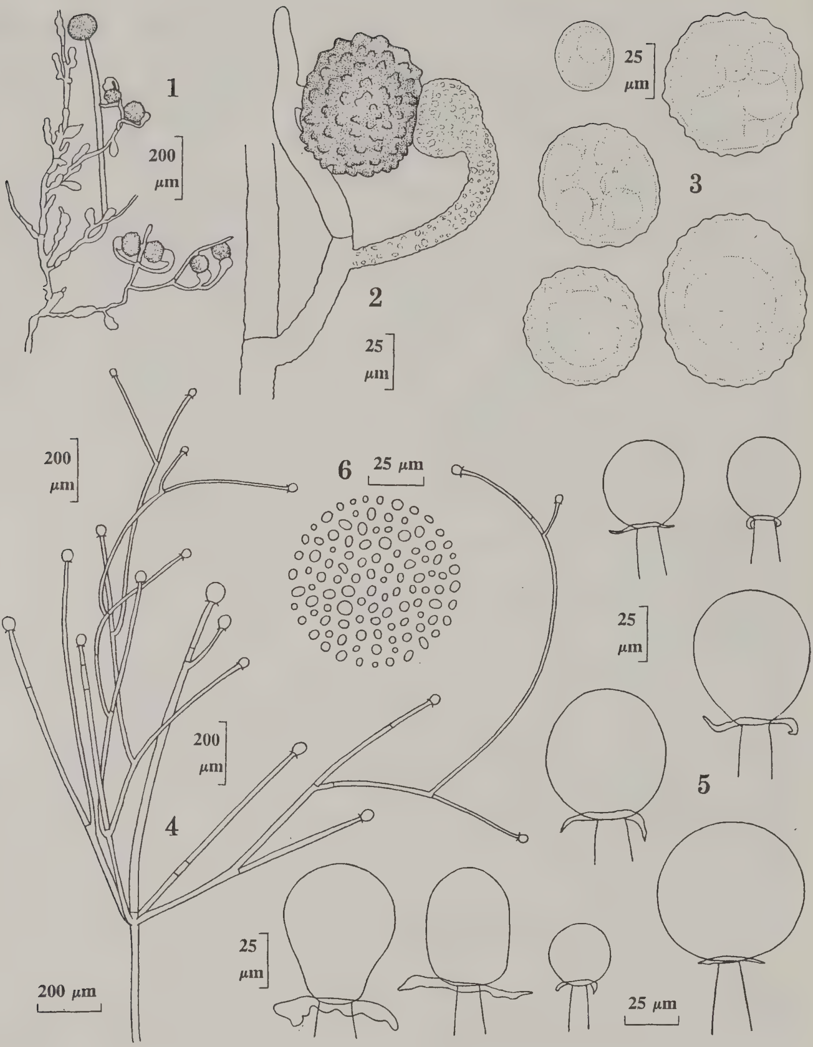

Fig. 2. *Zygorhynchus multiplex*. 1. A sporangiophore and several zygophores arising from submerged mycelium. 2. A zygosporangium borne between two unequal suspensors. Note that the larger suspensor is recurved, abruptly enlarged and slightly constricted at attachment to zygosporangium, and also heavily incrusted; smaller suspensor is straight and very short. 3. Detached zygospores. 4. A sporangiophore with a terminal sporangium and verticillate branches, some with sympodial or monopodial elongation. 5. Columellae of various shapes. 6. Sporangiospores.

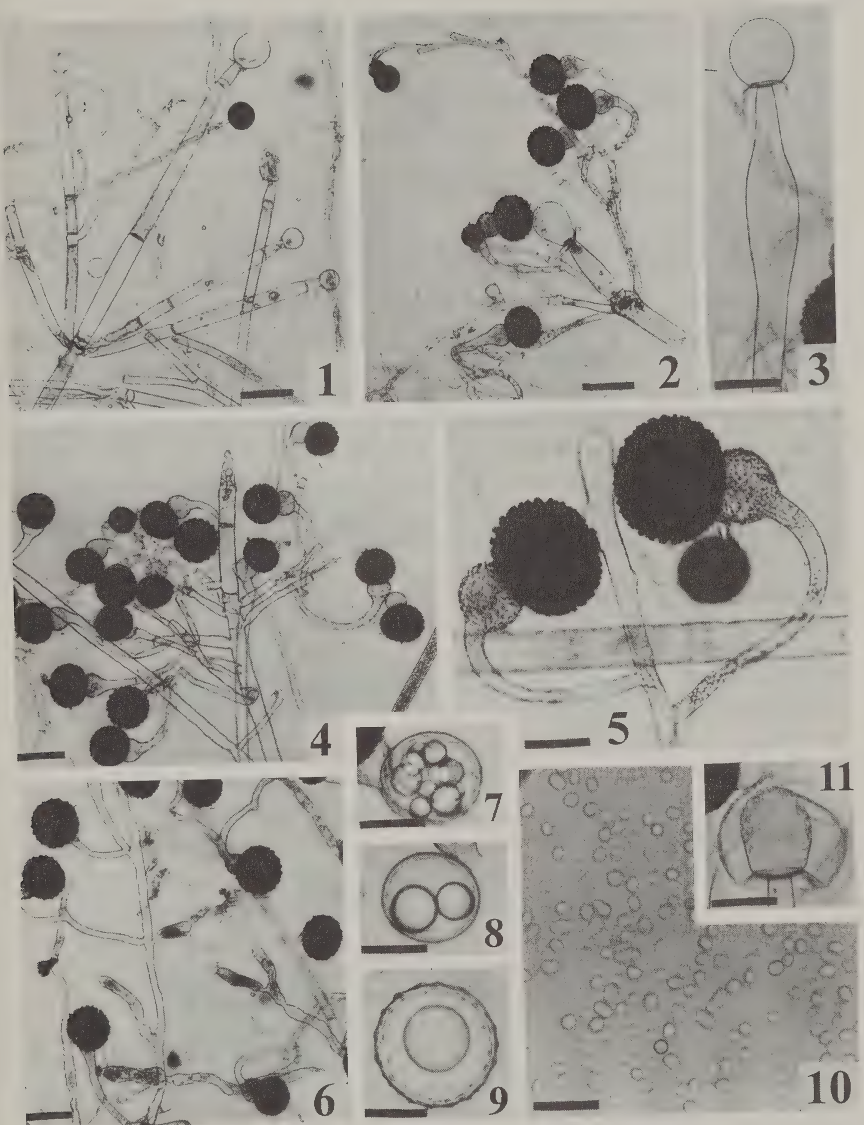

Plate I. *Zygorhynchus multiplex*. 1. Sporangiophore with a terminal sporangium and verticillate branches (bar = 100 μ m). 2. Sporangiophore with a terminal sporangium and verticillately branched zygophores (bar = 100 μ m). 3. A partly swollen sporangiophore (bar = 50 μ m). 4. Sporangiophore with a terminal sterile spine and many monopodially branched zygophores (bar = 100 μ m). 5. Enlarged zygophore branch showing two opposite zygosporangia borne between two pairs of unequal suspensors (bar = 50 μ m). 6. Zygophores arising from submerged hyphae (bar = 100 μ m). 7 - 9. Zygospores at different stages of maturity (bar = 50 μ m). 10. Sporangiospores (bar = 20 μ m). 11. A broken and emptied sporangium, note the large columella in relation to the sporangium (bar = 50 μ m)

submerged mycelia, main axes (17.5 -) 23.5 - 33 μ m wide, branches 6 - 23.5 μ m wide, both usually equal in width for most of the length but attenuated in the uppermost portion and slightly constricted just beneath the sporangium, sometimes swollen at places, hyaline, brownish to light brown, smooth to verrucose, of 4 main types: (1) branched or unbranched sporangiophores bearing sporangia only; (2) sporangiophores with a terminal sporangium and lateral branches bearing both sporangia and zygosporangia; (3) sporangiophores also with a terminal sporangium but with lateral branches bearing zygosporangia only; (4) terminal sporangium of the sporangiophores replaced by a sterile spine, lateral branches bearing only zygosporangia. In all four types, the primary branches can be single, in pairs, monopodial, or in whorls of 3 - 5, then repeatedly branching monopodially or sympodially, each branch ending in a sporangium or in a long or short spine. *Sporangia* borne terminally on the main axes or branches of the sporangiophores, globose to depressed-globose, 47 - 94 (- 106) μ m diam., non-apophysate, breaking or slowly dissolving, yellowish to brownish when young, dark brown when mature. *Columellae* mostly oval to subglobose or globose, sometimes pyriform, rarely ellipsoid, large as compared with the diameter of the sporangia, (28 -) 59 - 84 × (25 -) 47 - 73 μ m, or 56 - 83 μ m diam., subhyaline to light brown, smooth, with a distinct collar. *Sporangiospores* mainly short-oval to subglobose or globose, sometimes ellipsoid or oblong-ellipsoid, rarely subtriangular, allantoid or irregularly shaped, 2.5 - 5.5 × 2 - 5 μ m or 2 - 5.5 μ m diam., hyaline, grayish in mass, smooth, often with one to several oil droplets, becoming vacuolated in old cultures. *Chlamydospores* absent.

Zygosporangia developed throughout the colony but most abundant just above the substrate, globose to slightly compressed between the two suspensors, 37 - 83 μ m diam., dark brown to black when mature, with blunt wart-like projections, automatically cracking open at maturity. *Zygospores* broadly ovoid to subglobose, 32 - 78 × 27.5 - 71 μ m or 32 - 69 μ m diam., hyaline, thin-walled, almost smooth to crenate, with 1 - 14 oil globules when young, merging into 1 large globule when old. *Suspensors* unequal, smaller ones not inflated, straight, very short, 2.5 - 13 μ m high and 9 - 16 μ m wide, hyaline, smooth, usually nonseptate; the larger ones often bent and recurved to fuse with the gametangia produced on the same zygophore, 55 - 250 μ m long, slightly enlarging upward and abruptly inflated into a globose or short-oval shape, then constricted when touching the zygosporangium, 27.5 - 41 μ m diam. in the swollen part, 8.5 - 14 μ m at the base, light brown to orange-brown, often heavily incrusted, septa absent at first but 1 - 3-septate later. *Homothallic.*

The new species is characterized by its complicated sporangiophore construction. None of the known taxa of *Zygorhynchus* has sporangiophores composed of a main axis with a terminal sporangium which may or may not be replaced by a sterile spine, and many lateral branches which bear sporangia only or zygosporangia only, or both, and are either 3 – 5 verticillately, monopodially, sympodially, or irregularly branching one to several times. Verticillate sporangiophores or zygophores, and a terminal sterile spine replacing a terminal sporangium have never been reported in the genus. All but two species, *Z. japonicus* and *Z. multiplex*, have applanate columellae. The columellae of *Z. japonicus* are pyriform and rarely globose; whereas those of *Z. multiplex* are more variable, which are oval to subglobose or globose, sometimes pyriform, and rarely ellipsoid. Besides, columellae of *Z. multiplex* reach 84 μm in height, which is at least twice as high as those of the other species.

A key to all the recognized taxa in the genus, with synonyms attached to their related correct name, is presented as follows:

KEY TO SPECIES OF *ZYGORHYNCHUS*

1. Gametangia forming a zygosporangium arising from the same aerial hypha or sometimes on two different hyphae 2

1. Gametangia always arising from the same aerial hypha 3

2. Sporangia splitting open when mature; columellae applanate to globose, rarely conical and with a short apical projection; sporangiospores globose or subglobose, wall roughened; a hypha of a certain sex typically attracting a single hypha of the opposite sex; zygosporangia reddish brown to dark brown ....***Z. exponens*** Burgeff (1924)
   [synonyms: *Z. polygonosporus* Pišpek (1929), *Z. exponens* var. *smithii* Hesselt. *et al*. (1959)]

2. Sporangia not splitting open when mature; columellae pyriform, rarely globose, always without apical projection; sporangiospores ellipsoidal-ovoid, wall smooth; a single hypha of a certain sex often attracting several hyphae of the opposite sex; zygosporangia yellow, then brown to black .... ***Z. japonicus*** Komin. (1914)

3. Terminal sporangium sometimes replaced by a sterile spine; sporangiophores with many lateral branches which bear sporangia only or zygosporangia only, or combinations of both, primary branches single, in pairs, monopoidal, or in whorls or 3 – 5, then repeatedly branching monopodially or sympodially; columellae

variable but never applanate, reaching a height of 84 μm .... **Z. multiplex** R. Y. Zheng sp. nov. (this study)

3. Sporangiophores not as above; columellae typically applanate, at most 40 μm high 4
4. Not growing at or above 20℃, optimum temperature for growth and sporulation 0 – 15℃; sporangiospores fusiform .... **Z. psychrophilus** Schipper & Hintikka (1969)
4. Growing at or above 20℃, optimum temperature for growth and sporulation 15 – 25℃; sporangiospores not fusiform 5
5. Sporangiospores with one to several oil droplets; zygosporangia black when mature; larger suspensor abruptly inflated into globose or broadly oval shape, 28 – 57 μm diam. .... **Z. heterogamus** (Vuill.) Vuill. (1903)
   [basionym: *Mucor heterogamus* Vuill. (Vuillemin, 1886); synonyms: *M. neglectus* Vuill. (Vuillemin, 1887); *Z. phosphoreus* Pišpek (1929); *Z. macrocarpus* Y. Ling (1930); *Z. hennebergii* Naumov (1935)]
5. Sporangiospores not as above; zygosporangia brown to dark brown when mature; larger suspensor gradually inflated, not exceeding 27 μm diam. 6
6. Columellae always applanate; sporangiospores globose to subglobose, typically with one oil droplet in the center; azygospores absent .... **Z. californiensis** Hesselt. *et al.* (1959)
6. Columellae typically applanate, sometimes subglobose; sporrangiospores cylindric-ellipsoid, with 1 oil droplet at both ends; azygospores sometimes present .... **Z. moelleri** Vuill. (1903)
   [synonyms: *Mucor moelleri* (Vuill.) Lendn. (Lendner, 1908); *Z. vuilleminii* Namysl. (1910); *Z. vuilleminii* race *agamus* Namysl. (1910); *Z. dangeardii* Moreau (1912); *Z. bernardii* Moreau (1913); *Z. circinelloides* Pišpek (1929); *Z. viridis* Pišpek (1929); *Z. griseocinereus* Pišpek (1929); *Z. vuilleminii* var. *dangeardii* Zycha (1935); *Z. vuilleminii* var. *albus* Christenb. (1940); *Z. verruculosus* Tehon (1943)]

EXCLUDED SPECIES

Zygorhynchus amphibiorum (Schipper) Arx (1982)
Z. bacilliformis (Hesselt.) Arx (1982)
Z. indicus (Lendn.) Arx (1982)

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GLOMUS CAESARIS, A NEW ARBUSCULAR MYCORRHIZAL FUNGUS FROM THE KAISERSTUHL IN GERMANY

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SUMMARY

Glomus caesaris is a new species in the Glomales forming globose, yellow brown spores of 156-212 µm diameter. The spores have one wall with 5 layers of which spore wall layer 2 swells from 1-3 µm to 10-30 µm when spores are mounted in lactic acid based media. Wall layers 1-3 are hyaline and are in total about 3-7 µm thick, wall layer 4 is laminated, yellow-brown and 3-6 µm thick, while the inner wall layer 5, 0.5-1.0 µm thick, closes the pore at the spore base. *Glomus caesaris* spores superficially resemble those of *G. caledonium* from which they are distinguished by the number of spore wall layers, the swelling of the second wall layer in lactic acid based media, by the reaction of this layer in Melzer´s reagent, and by differences in the spore attachment.

ZUSAMMENFASSUNG

Eine neue Art in den Glomales wird beschrieben. *Glomus caesaris* bildet kugelförmige, gelb-braune bis braune Sporen von 156-212 µm Durchmesser. Die Sporen besitzen 5 Wandschichten. Die zweite Wandschicht schwillt in Milchsäure-basierten Medien von 1-3 µm auf 10-30 µm Dicke an. Die äußeren 3 Wandschichten sind hyalin und zusammen etwa 3-7 µm dick, die vierte Wandschicht ist laminiert, gelb-braun und 3-6 µm dick. Die innerste Wandschicht schließt die Pore des Hyphenansatzes. Die Sporen von *Glomus caesaris* ähneln am ehesten denen von *G. caledonium*, von denen sie sich unterscheiden durch die Anzahl der Wandschichten, dem Anschwellen der zweiten Wand in Milchsäure-basierten Medien, der Purpur-Färbung derselben Wandschicht in Melzer's Reagenz, und den Unterschieden im Hyphenansatz. *Glomus caesaris* wurde benannt nach seiner Fundregion Kaiserstuhl, welcher im Mittelalter lateinisch ‚*solium caesaris*' genannt wurde.

INTRODUCTION

In the frame of studies on the diversity of arbuscular mycorrhizal fungi under different cropping systems in the Rhine Valley of Germany, samples were taken from the rhizosphere of grape plants, near the village Vogtsburg in the Upper Rhine Valley. This volcanic area covered by periglacial loess sediments was called '*solium caesaris*' (the Throne of the Caesar) in the middle ages and today is called 'Kaiserstuhl'. We dedicate this new species to this natural reserve of Germany.

MATERIALS AND METHODS

Undisturbed soil cores (sampling depth 10 cm) were taken in October 2000 from a vineyard in the Kaiserstuhl area of South-Western Germany. Eight trap cultures were established in December 2000. Pots (300x200x200 mm) with a 20 mm thick drainage mat were filled with 3 kg of an autoclaved substrate (Terragreene-loess mixture; 3:1; pH-H_2O 6.7; available P (Na-acetate) 0.6 mg kg^{-1}; available K (Na-acetate) 42 mg kg^{-1}). The mycorrhizal inoculum (nine 20 g cores of undisturbed soil per pot) was placed at the surface and covered with another kg of autoclaved substrate. Three two week old, AMF seedlings of *Lolium perenne* L., *Trifolium pratense* L. and *Plantago lanceolata* L. were randomly planted into every pot. *Trifolium pratense* plants were inoculated with 1 ml (1:5 dilution overnight culture) of *Rhizobium trifolii* (DSM 30138, DSMZ, D-38124 Braunschweig, Germany). An automated watering system (Tropf-Blumat, Weninger GmbH, A-6410 Telfs) was installed.

In July 2001, *Glomus caesaris* sp. nov. had sporulated in the trap cultures. Several spore cultures, each with a single viable spore of *G. caesaris* were inoculated into 1 ml pipette tips filled with an autoclaved mixture of Quartz sand and loess (1:1). *Hieracium pilosella* L. was seeded at the top of the single spores. After 4 weeks, the pipette tips were cut in the middle and each placed in 320 ml pots that contained the autoclaved Terragreene-loess mixture mentioned above. In April 2002, the spore production and mycorrhizal colonisation were controlled using methods as proposed by Brundrett et al. (1994).

Morphological properties of spores and their subcellular structures are based on observations of spores mounted in polyvinyl alcohol-lactic acid-glycerol (PVLG; Koske and Tessier, 1983), a mixture of PVLG and Melzer's reagent (Brundrett et al., 1994), a mixture of lactic acid to water at 1:1, and water only. The terminology of the spore structure is that suggested by INVAM (International Culture Collection of Arbuscular and Vesicular-Arbuscular Endomycorrhizal Fungi, see homepage: www.invam.caf.wdu.edu). Spores preserved in 5 % formalin and specimens mounted in PVLG and the mixture of PVLG and Melzer's reagent were deposited in the herbaria indicated below.

LATIN DIAGNOSIS

Glomus caesaris sp. nov. Sieverd. & Oehl (Fig. 1 & 2)

Sporocarpia ignota. Sporae fulvae, globosae, 156 – 212 (ad 240) μm in diam. Tunica sporarum cum 5 stratis; stratum primum hyalinum, in aquam < 1 μm crassum,. Stratum secundum et tertium hyalinum, quisque 1-4.5 μm crassum, quisque laminatum, rara separata sunt. Stratum secundum in medium cum acido lacteo intumescit usque ad 10-30 μm distat a strato tertio. Stratum quartum fulvum ad bruneum, laminatum, 3-6 μm crassum, non dividi ex strato tertio potest. Stratum quintum dahaeret at stratum quartum, < 1μm crassum. Stratum quintum porum hyhae adhaerentae claudet. Hypha adhaerenta communis singula, 15-24 μm diam ad coniunctio, minnet a 9-16 μm diam en distantiam 25-60 μm. En hypham adhaerentam stratum internum quartum concreta incondita formant, item hypham ex interiore parte frequenter occludet. Formans mycorrhizam cum arbusculis et vesiculis.

DESCRIPTION

Sporocarps unknown.

Spores formed singly in soil. Spores yellow-brown to brown in a dissecting microscope, globose, 156-212 (240) μm in diam., seldom subglobose.

Spore wall in total 9-10 μm thick, consisting of 5 layers in one wall group (Fig. 1): The outer wall layer 1 is hyaline, thin (< 1 μm thick) and has a granular, roughened appearance. Wall layer 2 is hyaline, finely laminated and 1-3 μm thick in water; in PVLG mountants or lactic acid this layer swells up to 10-20(-30) μm giving the appearance of an irregular flexible halo; it stains pink to reddish purple in Melzer's reagent, appearing pale pink when laminae swell. Wall layer 3 is usually adherent to layer 2. The two layers seldom separate. Layer 3 is hyaline to light yellow or with a greenish tint, finely laminated, 1-4.5 μm thick, does not stain in Melzer's reagent. Wall layer 4 rarely separates from layer 3; it is yellow-brown to brown, laminated, 3-6 μm thick, not reactive to Melzer's reagent. Wall layer 5 sometimes separates from layer 4 and consists of at least two laminae, light yellow to brown, 0.5-1 μm thick; no reaction to Melzer's reagent.

Subtending hypha generally single; seldom two hyphal attachments are seen, straight or curved, tapering from 15-24 μm at the spore base to about 9-16 μm diameter for 25-60 μm distance. All four outer spore wall layers continue up to this distance. Spore wall layer 4 is the main wall layer in the subtending hypha, 3-4 μm thick at the base of the attachment; the outer hyaline layers, 2-5 μm thick at the base, taper in thickness within short distance from base of the attachment.

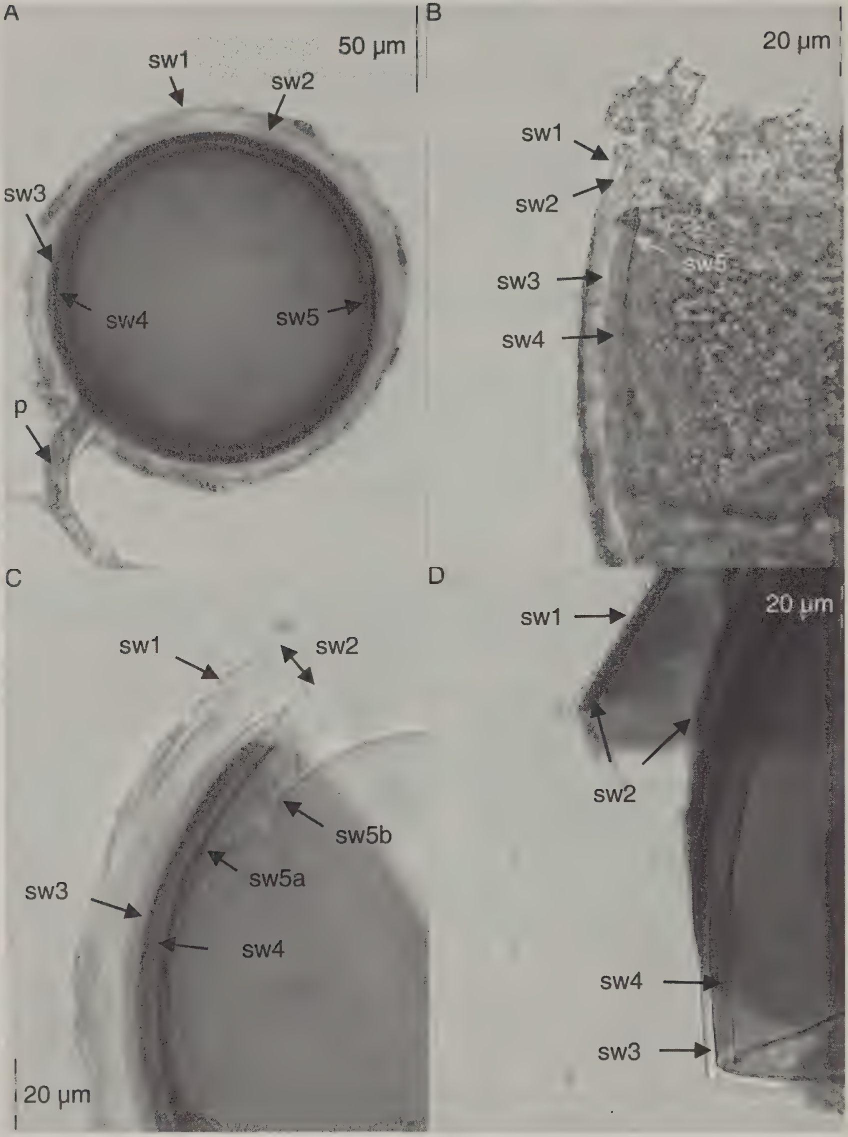
A
50 μm
sw1
sw2
sw3
sw4
sw5
p
B
20 μm
sw1
sw2
sw3
sw4
sw5
C
sw1
sw2
sw5b
sw5a
sw3
sw4
20 μm
D
sw1
20 μm
sw2
sw4
sw3

Figure 1: Spore characteristics of *G caesaris*. A. Spore mounted in PVLG, note the granular appearance of spore wall layer 1 (sw1), the swollen layer sw2, and the proliferations (P) within the subtending hypha. B. Broken spore mounted in water, spore wall layers not swollen. C. Broken spore mounted in PVLG with irregular swollen sw2 and granular sw1, laminated subhyaline sw3, pigmented laminated sw4, and outer (sw5a) and inner lamina (sw5b) of wall layer 5. D. Broken spore mounted in PVLG + Melzer's reagent; note the stained wall layer 2 (sw2) and granular outer wall layer 1 (sw1).

Spore pore closed by wall layer 5, which is thin (<1 µm) and consists of at least two laminae. In fully developed spores, the laminae of this layer are closely adherent to each other and to layer 4 and enter into the hyphal attachment forming a funnel-shaped septum (Fig. 2 A), or the laminae split (Fig 2 B), or wall layer 5 separates totally and does not enter into the spore base (Fig. 2 C). Additionally, the subtending hypha is often completely closed by irregular proliferations of the innermost yellow-brown attachment wall layer (continuation of spore wall layer 4) starting at a distance of 5-60 µm from the attachment base, and over a distance of up to 90 µm in the subtending hypha.

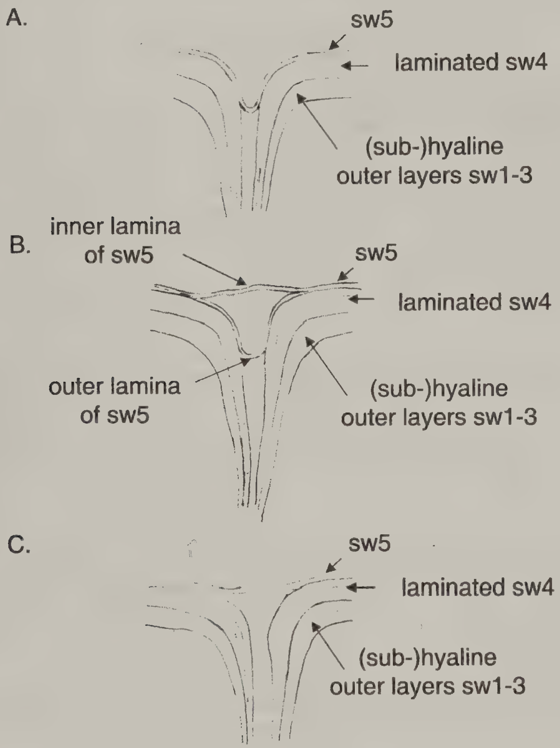
A.
sw5
laminated sw4
(sub-)hyaline outer layers sw1-3
B.
inner lamina of sw5
sw5
laminated sw4
outer lamina of sw5
(sub-)hyaline outer layers sw1-3
C.
sw5
laminated sw4
(sub-)hyaline outer layers sw1-3

Figure 2: Closure of the pore at the spore base in *Glomus caesaris*. A. Slight funnel-shaped formation of spore wall layer 5 (sw5). B. Splitting of laminae of sw5 at the spore base. C. Spore wall layer 5 separated from layer 4 (sw4), and not entering into spore base.

Forms vesicular arbuscular mycorrhizae.

Etymology: Latin: *caesaris* (genitive of caesar, belonging to caesar) referring to the Latin middle age name of the area where the species was first found.

Type: Isolated from pot culture at the Institute of Botany, University of Basel, Basel, Switzerland. Holotype Slide Nr. 15-191: Z/ZT, Isotypes: Z/ZT, FB, OSC.

Distribution: *Glomus caesaris* was isolated from a trap pot culture inoculated with a soil sample originating from a vineyard at the Vogelsang Pass near Vogtsburg, Kaiserstuhl area, Germany. *Lolium perenne* L., *Plantago lanceolata* L. and *Trifolium pratense* L. were the hosts for the trap pots. Isolates were established on *Hieracium pilosella* L., from which the type material was extracted. *Glomus caesaris* formed vesicular arbuscular mycorrhiza with these plant species.

DISCUSSION

There are several morphological features of the spores of *Glomus caesaris* that are characteristic for this new species:

The second spore wall layer of *G. caesaris* swells from 1-3 μm to 30 μm thickness when spores are mounted in lactic acid based mountants, and this layer is reactive to Melzer's reagent. Hence, this layer has reactions similar to wall layer 2 of *Scutellospora biornata*, Spain, Sieverding & Toro (1989) reported to swell in lactophenol, and to stain reddish-purple in Melzer's.

Wall layer 5 closes the pore of the hyphal attachment. We consider wall layer 5 to be a separate layer and not laminae of wall layer 4 because it often separates from layer 4 and forms a semi-flexible wall. Usually at least two fine laminae are visible in spores mounted in PVLG. The laminae are either adherent or separated from each other and close the pore of the attachment as described (Fig. 2).

Spores of *G. caesaris* have irregular proliferations within the attached hypha, a characteristic, to our knowledge, not described for other Glomales species. The irregular thickenings within the subtending hypha start at some distance from the base of the attachment and do not always completely close the subtending hypha. We observed such proliferations or in-growth in the sporogenous hyphae in 97,5% of all spores. First signs of slight thickening were visible in the remaining 2.5 % indicating a young stage of wall layer proliferation. Hence, we believe that such thickening is a characteristic feature of the species.

Spores of *Glomus caesaris* overlap in size and in colour with spores of *G. caledonium* (Nicolson & Gerdemann) Trappe and Gerdemann (Gerdemann and Trappe, 1974) although spores of *G. caesaris* are generally smaller and darker. Spores of *G. caesaris* are differentiated from *G. caledonium* by the number of spore wall layers (5 wall layers vs. 4), by the swelling of the second wall layer in lactic acid based mountants, and the reaction of the second wall layer in Melzer's reagent. Spore walls of *G. caledonium* do not swell and do not stain. The closure of the hyphal attachment also differs: *Glomus caledonium* has a thick, 2-5 μm, clearly visible septum which is formed by a considerable part of the laminae of the pigmented innermost wall layer 4, often at some distance from the spore base within the hyphal attachment. The closure of the pore in *G.*

caesaris by the thin laminae of spore wall 5 can have different forms as shown in Fig. 2.

Spores of *Glomus dimorphicum* (Boyetchko and Tewari, 1986) may also overlap in size and colour with *G. caesaris*. However, the outer hyaline layer of *G. dimorphicum* is evanescent and often not present on mature spores or on field isolations. There are similarities in the inner wall layers and the closure of the hyphal attachment, however, the septum of *G. dimorphicum* spores often extends deeper into the subtending hyphae. Dimorphism has not been observed in *G. caesaris.*

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A TAPHRINA ON DRYOPTERIS CARTHUSIANA IN SLOVAKIA

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Abstract: A species of *Taphrina* was collected on *Dryopteris carthusiana* in Slovakia for the first time. It caused small yellow-brown, thickened, blister spots on living leaves. The fungus was identified as *Taphrina vestergrenii* that is quite common on *Dryopteris filix-mas* in the northern Europe.

Key words: *Taphrina vestergrenii,* Taphrinaceae, Ascomycota

Members of the genus *Taphrina* fungi are parasitic on higher plants and ferns but those on ferns are very rare. Most of them occur in northern Europe and are associated with species of *Dryopteris* (Mix, 1949, Gjaerum, 1964, Salata, 1974). There are no data on any *Taphrina* species associated with ferns from Slovakia although *Taphrina filicina* on *Dryopteris carthusiana* was reported from the Polish part of Vysoké Tatry Mts. (Sałata, 1974).

During our mycological survey of Tatra Mts., among another microfungi, a *Taphrina* parasiting on *Dryopteris carthusiana* (Vill.) H. P. Fuchs was collected in shady places along the path in the valley of Kamenistá dolina, Západné Tatry Mts. Its abundance was quite high and the species was re-collected in the same site next year.

Fungus description

The symptoms on leaves are discreet, starting as pale-green, slightly thickened spots, up to 2-3 mm diam. Later the thickened tissue are hypertrophy changed causing convex sharp border blister spots up to 5 mm in diameter on the adaxial side of the leaf (fig. 1A). The blister spots are round or shapeless, yellow or pale brown. In the course of development of asci the cuticle ruptured and the mature asci are formed as a white cover on the surface of blister spot (fig. 1A).

Mycelium grows intercellularly beneath the cuticle. The cells of mycelium are thin, various length and shape are divided by layered septa (fig. 1B). During the fungus maturing, the cells of intercellular mycelium become thickened, disintegrated and short thick-walled round ascogenous cells are formed (fig. 1C.). Lately ascogenous become longer and narrow and form close palisade layer beneath the cuticle (fig. 1D). Maturing the ascogenous cells formed asci (fig. 1E).

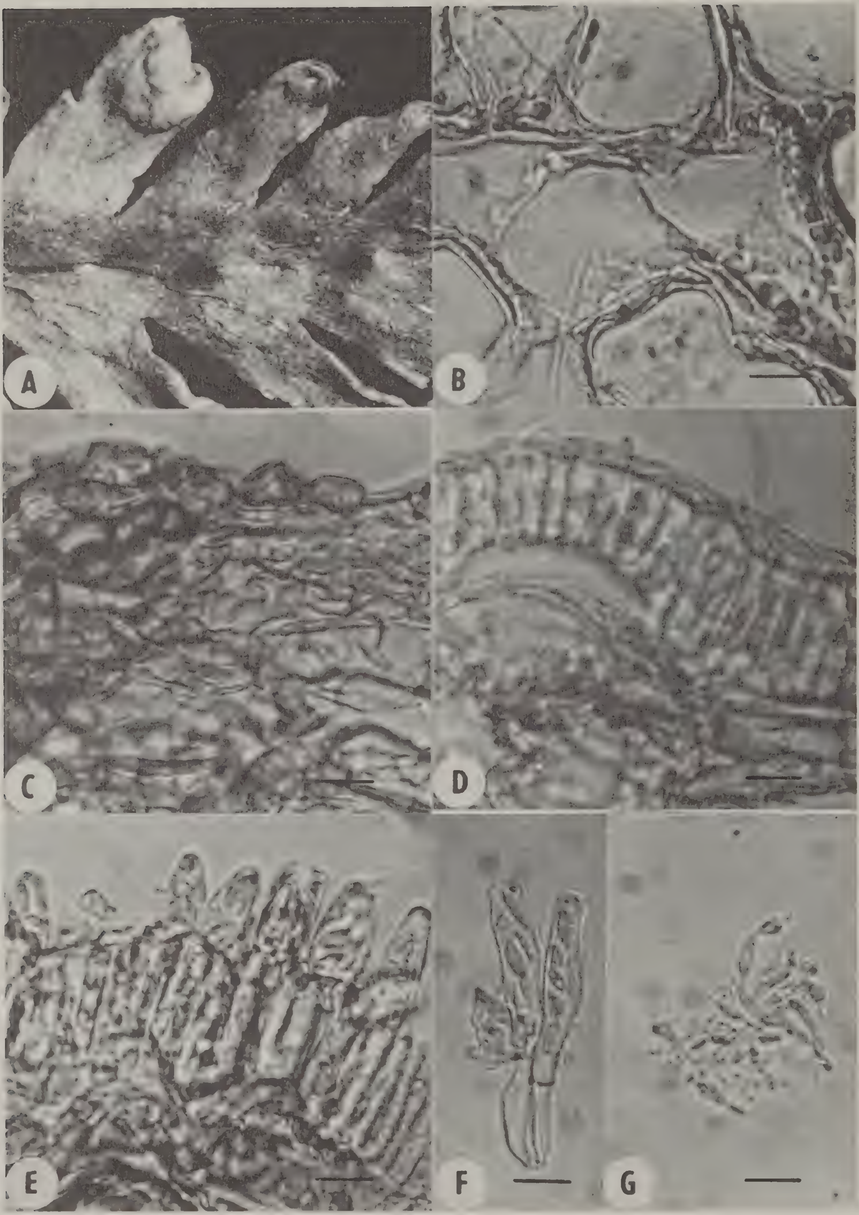

Fig 1A-G *Taphrina vestergrenii* on *Dryopteris carthusiana*. A: Thickened blister-like spots on leaves (10x); B-G. Various stages of ascus developement: B-C: intercellular mycelium and ascogennous cells, D-E: palisade layer and asci development, F: asci with ascospores, G: ascospores budding into blastospores (bars = 10 μm).

ASCI are epihyllous or amphigenous, clavate, rounded or truncate at the apex, with a stalk cell on the base, 8-spored, 24-39 x 8-12 µm. Stalk cells cylindrical, 9-23 x 5-10 µm, truncate, pointed or white rounded below. ASCOSPORES are ellipsoid or fusiform, 8-9 x 2-3,5 µm, often budding into blastospores, 3 x 1,5 µm (fig. 1F). Often the asci are closely packed and both asci and stalk cells show an irregular contour (fig. 1F).

SPECIMENS STUDIED: Západné Tatry Mts., valley of Kamenistá dolina, on *Dryopteris carthusiana* leaves, 1400 m, July 23, 2001, W. Mułenko (SAV); ibidem, July 9, 2003, K. Bacigálová (SAV).

Fungus identity

Taphrina species are parasitic on higher plants and ferns, forming mycelium subcuticularly, intercellularly, intercellularly and subcuticularly or within the epidermal cell wall. The parasitic mycelium of *Taphrina* species on *Dryopteris carthusiana* grows subcuticularly in the intercellular spaces of leaf tissue. The asci provided with stalk cells are formed as a palisade layer beneath the leaf cuticle epiphyllous or amphigenous.

Sadebeck (1893) accepted 4 species of *Taphrina* on ferns but no one of them associated with *Dryopteris carthusiana*. Mix (1949) presented 10 species on *Dryopteris* sp. within *Taphrina*, five of them, *T. fusca*, *T. athyrii*, *T. vestergrenii*, *T. thaxteri*, *T. californica*, forming ascus basal stalk-like cells.

Table 1. Comparison of species of *Taphrina* associated with ferns forming stalk-like ascus basal cells

Taphrina	host	asci	ascus basal cells	spores
athytii	*Athyrium filix-femina* *Dryopteris carthusiana*	13-17x5,5-10	4,5-8x5-8	2,5-6x2-5
fusca	*D. rigida, D. carthusiana*	19-27x4-8	15-34x4-7	3,5-7x2-3,5
polystichi	*Polystichum setiferum*	21-53x5-11	5-17x4-8	3-6x2-4
	P. acrostichiodes	23-53x4,5-8,5	13-23x4-7	3-6x2-4
vestergrenii	*D. filix-mas*	23-50x6-10	10-23x4-10	3,5-6x2,5-4
vestergrenii	*D. carthusiana*	24-39x8-12	9-23x5-10	8-9x2-3,5

While comparing symptoms and asci of our fungus on *Dryopteris carthusiana* with another taxa, we eliminated *Taphrina thaxteri* Mix from Trinidad causing unthickened spots on *Dryoptris poiteana* and North American *T. californica* Mix causing small to large (up to few cm diam.) orange-brown galls on leaflets, midribs and petioles of *Dryopteris arguta*.

Taphrina athyri Siemaszko on *Dryopteris carthusiana* collected in Caucasus Mts. (Salata, 1974) distinguishes from our fungus by having different size and shape of asci (Tab. 1).

Taphrina fusca Giesenh., reported from Albania and Sicily on *Dryopteris rigida* and from North America on *D. carthusiana* var. *americana* and *D. carthusiana* var. *intermedia*, causes small, up to 5 mm in diam., fleshy pale green-yellowish galls on living leaves (Mix, 1949). It is very similar but Slovak collections have bigger asci and shorter ascus basal cells.

Taphrina polystichi Mix, a widely distributed North American species on *Polystichum acrostichoides* (Mix, 1949) was collected on *Polystichum setiferum* in Europe in France (Schneider, 1986). Yellow-brown, unthickened or thickened spots on leaves, up to 10 mm diam., and asci are similar to our collections from High Tatra Mts. But *T. polystichi* has not been collected on *Dryopteris* sp. in Europe and its host *Polystichum setiferum* is not present in Slovakia.

The commonest European species on ferns, *Taphrina vestergrenii* Giesenh. causes thickened blister-like spots (galls), up to 5 mm diam., on living leaves of *Dryopteris filix-mas*. Mycelium is intercellular and subcuticular, asci are 23-54 x 6-10 µm (30-45 x 8-10) with basal cells 9-21 x 4-8,5 µm, spores 7 x 3 µm. Characters of fungus collected on *D. carthusiana* in High Tatra Mts. in Slovakia, such as lesions on leaves, size and shape of asci and ascus basal cells correspond with data by Sałata (1974) and show that our collections belong to *T. vestergreni* (table 1, fig. 1F).

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LACTARIUS CHICHUENSIS AND L. HIRTIPES, TWO EASILY CONFUSED SPECIES[*]

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Abstract: Two species of the genus *Lactarius* described from Yunnan, China, *L. chichuensis* and *L. hirtipes* are compared in this study based on the critical examination of the holotypes and additional material. They are very similar in the field but can be distinguished from each other by the spores and the stipe cortex and pileus trama. The detailed descriptions and illustrations of the two species are provided. Both taxa belong to subgen. *Russularia* sect. *Theiogali.*

Key words: *Lactarius* subgen. *Russularia* sect. *Theiogali*, types, rosettes

The species *Lactarius chichuensis* W.F. Chiu was described from Yunnan, China and named after the type locality ("Mt. Chichu"). It was regarded as a species characterized by the small spores ornamented with parallel ridges and put into sect. *Pruinosi* (Quél.) Bataille subsect. *Piperati* (Fr.: Fr.) Konrad (Chiu, 1945). In 1991, *L. hirtipes* J.Z. Ying was described from the same locality (Jizushan = "Mt. Chichu"). The species is easily recognized by the small reddish-brown fruiting bodies with fragrant odor and reticulate spores and was placed in sect. *Russularia* Fr. ex Burl. by Ying (1991). After publication, no additional records of these species are known. During the recent years we have had opportunity to investigate in Jizushan and rediscovered both species, finding it difficult to distinguish them in the field. However, the microscopic differences between them are rather obvious. Based on the critical examination of the holotypes and additional material collected from the type locality, the detailed descriptions of the two species

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and the distinguishing characters between them are reported herein.

Color notations are from Kornerup & Wanscher (1978). For notations and abbreviations of data on spores we refer to Yang (2000). The dimensions of spores do not include the ornamentation. The concepts of macrocystidia and pseudocystidia are according to Hesler & Smith (1979).

Lactarius chichuensis W.F. Chiu, Lloydia 8(1): 38, Fig. 10 (1945). Fig. 1-8

Pileus 3-3.5 (-6.5) cm in diam., broadly convex-depressed with the margin spreading, with or without a central papilla; surface glabrous, not greasy, sometimes pruinose, azonate, rugose; margin translucently sulcate (striae up to 5 mm long when mature); color reddish brown or darker (9D5-9D6), paler on margin or when mature; cuticle continuous (not rimulose-areolate), smooth. Context concolorous or sub-concolorous with the pileus, brittle; taste slightly acrid to acrid; odor not distinctive. Latex milk-white, soon becoming whey-like in air, unchanging and not staining, mild at first, acrid in several seconds, copious, as white granules on the lamellae when dry. Stipe 3-5.5 cm long, 0.4-0.7 (-0.9) cm thick, equal to enlarged below, central to eccentric, fragile, soon hollow, glabrous, concolorous with the pileus or paler, dry; base with short strigose hairs (1-3 mm long) or almost naked. Lamellae crowded, narrow, 2-3.5 mm broad, concolorous with the pileus or darker, shortly decurrent, often darkly spotted, with many tiers of lamellulae, brown (close to 7E4) when dry.

Spores deposit very pale cream. Basidiospores (from gill) [304/9/8] (5.7-)6.2-7.5(-8.5) × (5.2-)5.7-6.6(-8.0) μm [Q = (1.00-)1.05-1.19(-1.25), **Q** = 1.12 ± 0.05] (Type: [50/1/1] (5.2-)5.3-6.3(-8.0) × (5.7-)6.0-7.0(-8.5) μm [Q = 1.00-1.22, **Q** = 1.12 ± 0.05]), broadly ellipsoid to subglobose; ornamentation amyloid, zebroid, composed of parallel ridges and scattered warts; prominences up to 1 μm high. Basidia 34-55 × 8.5-12.5(-14) μm, 4-spored; sterigmata 3-6 μm long. Pleurocystidia: macrocystidia 47-90 × 6-12 μm, subcylindrical to lanceolate, acute, scattered to numerous, conspicuous, projecting 15-30 μm beyond basidia, with refractive masses at the apex; pseudocystidia scattered, filamentous, 3-4 μm thick, hyaline, slightly refractive, often forked, not projecting or projecting 5-15 μm. Cheilocystidia as reduced basidioles, 25-30 × 5-6 μm, fusoid to fusoid-ventricose. Gill trama filamentose, lacking rosettes, lactifers inconspicuous. Pileus trama heteromerous. Pileipellis a layer or zone of versiform inflated cells, up to 40 μm in diam.,

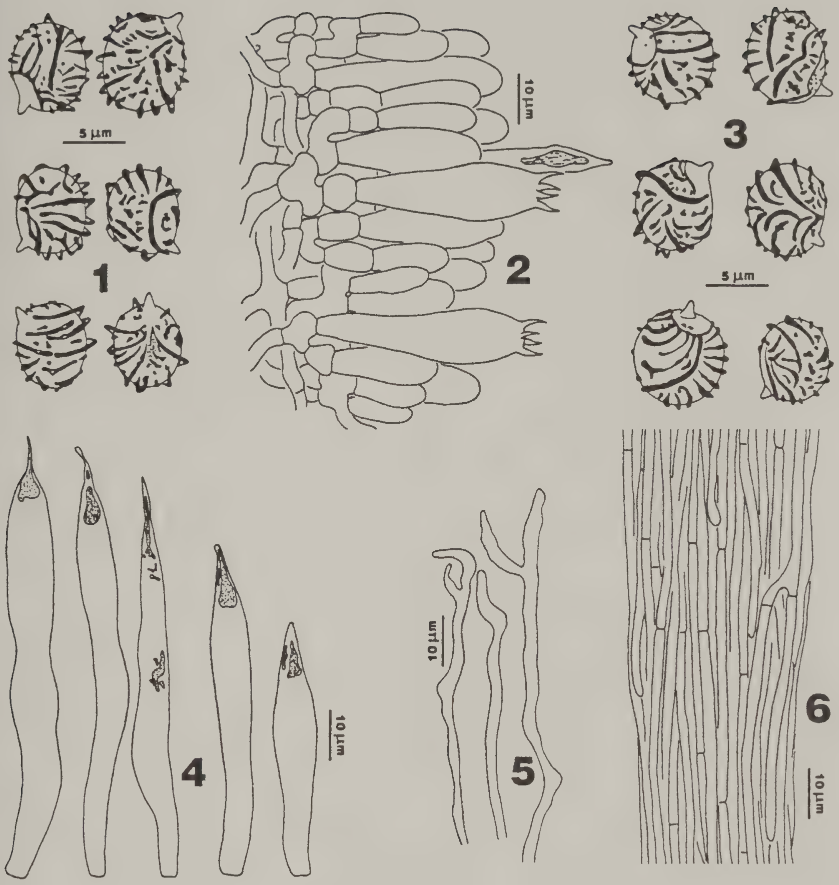


Fig. 1-6. *Lactarius chichuensis*

Holotype: 1. Basidiospores;

HKAS 38807: 2. Hymenium; 3. Basidiospores; 4. Macrocystidia;

5. Pseudocystidia; 6. Section of hair at stipe base

mostly 15-25 µm in diam., terminal elements stubby-cylindrical, 15-30(-70) × (4-)6-8 µm, not regularly anticlinally arranged, dry, no hyphal incrustations observed. Stipe cortex with rosettes. Stipitipellis of longitudinally arranged inflated hyphae, thin-walled, terminal elements scattered, stubby-cylindrical or cylindrical, 12-48 × 4-9 µm, periclinally arranged. Hairs at the stipe base composed of un-inflated parallel hyphae, 2-3 µm thick, compactly arranged, rarely branched, septate.

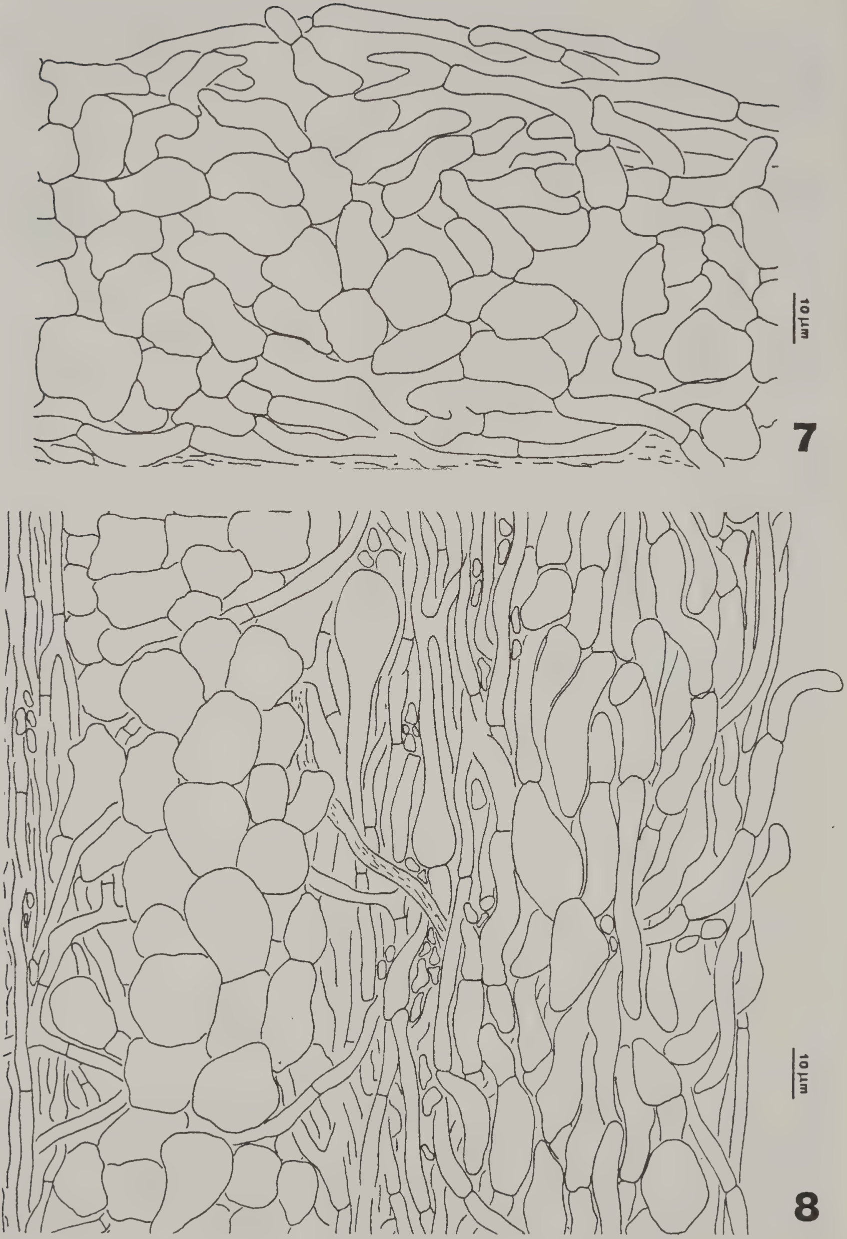


Fig. 7-8. *Lactarius chichuensis* (HKAS 38807)

7. Section through pileipellis;

8. Section through stipitipellis and cortex (right side - stipe surface)

Habit and Habitat: Solitary, very common under Fagaceae (*Castanopsis* spp., *Quercus* spp.) forest during summer.

Holotype: Yunnan: Binchuan ("Pinchuan"), Jizushan ("Mt. Chichu"), 8. IX. 1938, C. C. Cheo (HMAS 4135 = Tsinghua 8135)

Additional material: Yunnan: Qujing, Market, 12. VII. 1998, X. H. Wang 363 (HKAS 31957); Kunming, Xishan, 2300 m, 30. IX. 1996, P. G. Liu 4343 (HKAS 32081); Zhaotong, Yongshan, 5. X. 2000, A. H. Rong 15 (HKAS 37454); Zhaotong, Yongshan, 13. IX. 2000, A. H. Rong 39 (HKAS 37455); Kunming Botanical Garden, 1900 m, 12. VII. 2000, X. H. Wang 1013 (B) (HKAS 38803); Kunming, Heilongtan Park, 1900 m, 26. VI. 2000, X. H. Wang 1202 (HKAS 38804); Binchuan, Jizushan, 2250 m, 14. VII. 2001, X. H. Wang 1236 (HKAS 38806); 1243 (A) (HKAS 38807); Qujing, Zhanyi, Zhujiangyuan, Maxiongshan, 2200 m, 23. VIII. 2001, X. H. Wang 1347 (HKAS 38808); **Fujian**: Wuyishan, Huanggangshan, 1640 m, 23. VIII. 2000, Y. Liu 000823039; Wuyishan, Huanggangshan, 1640 m, 12. IX. 2001, Y. Liu 010912042.

Observation: The holotype consists of only one basidiocarp in poor condition. Thus, only the spores were observed. All macroscopic and other microscopic characters mentioned above are observed from the additional material.

The "tawny" tinge of the pileus described by Chiu is probably not the fresh color. The stipe of the holotype is not pubescent but glabrous. The stipe of our additional material from the type locality is glabrous except the base with short strigose hairs.

The collection HMAS 60174 (Binchuan, Jizushan, VIII. 1990, X. L. Mao 2174) under the name *L. chichuensis* is based on a misidentification since the spores are not zebroid and the pileipellis is not cellular.

The cellular pileipellis suggests the placement of *L. chichuensis* into subgen. *Russularia* (Fr. ex Burl.) Kauffman sect. *Theiogali* Hesler & A. H. Sm. as defined in Hesler & Smith (1979) or sect. *Russulares* Fr. as defined by Singer (1986). *L. chichuensis* is distinct among the members in sect. *Theiogali* due to the zebroid spores.

Lactarius hirtipes J.Z. Ying, Acta Mycol. Sinica 10 (3): 192, Fig. 2 (1991). Fig. 9-14

Pileus 2-4 (-6) cm in diam., broadly convex-depressed, with or without a central papilla; surface glabrous, azonate, subhygrophanous, radially rugose, occasionally slimy; margin sometimes translucently sulcate, reddish brown, paler or darker, 9E6-9D6 when young, 9E8, 9D6 to 7C7 when mature, cuticle continuous (not rimulose-areolate). Context concolorous or sub-concolorous

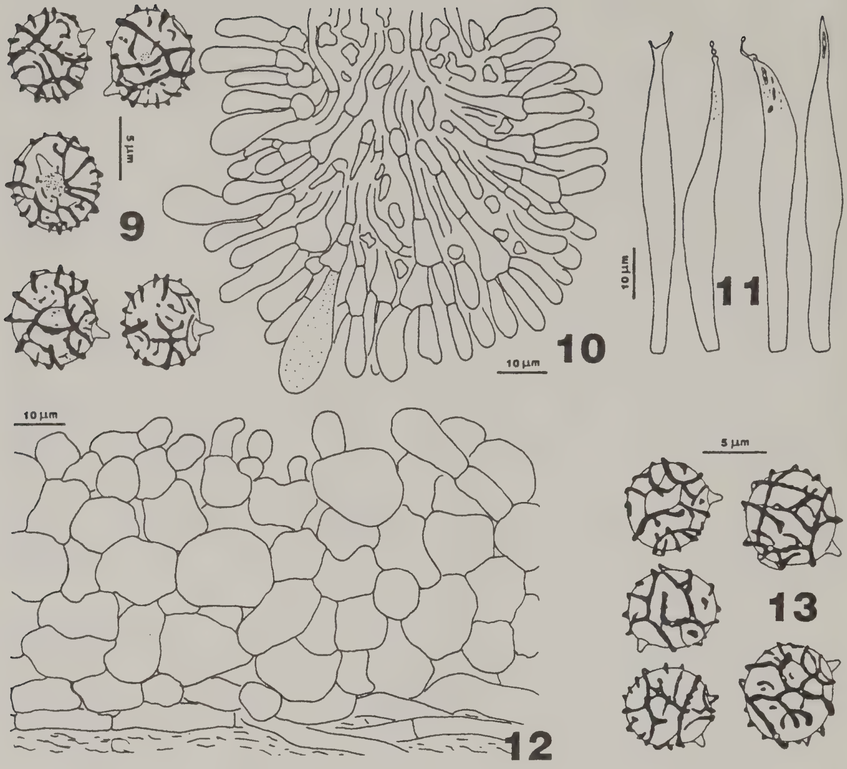
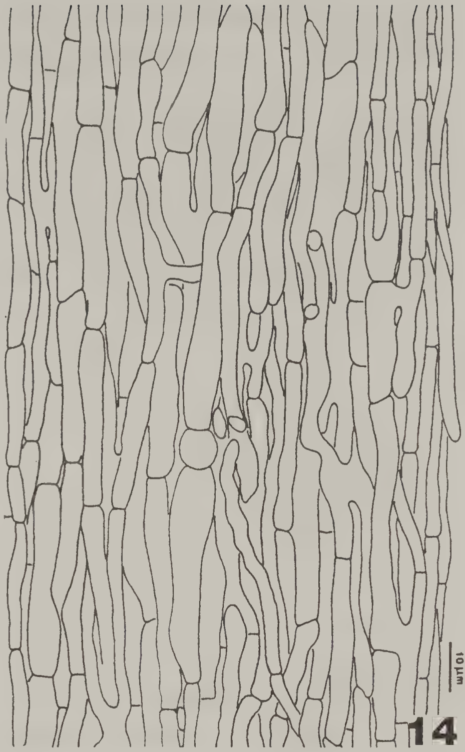


Fig. 9-13. *Lactarius hirtipes*
Holotype: 9. Basidiospores; 10. Lamellae edge;
11. Macrocystidia; 12. Section through pileipellis
HKAS 38819: 13. Basidiospores

with the pileus, brittle; taste mild to faintly acrid; odor not distinctive. Latex milk-white soon becoming whey-like in air, unchanging and not staining, mild to acrid, copious. Stipe 2-8 cm long, 0.3-0.6(-0.9) cm thick, enlarged below, central, occasionally eccentric, fragile, soon hollow, surface concolorous with the pileus or paler, dry; base (1-2 cm) with conspicuous strigose hairs (1-8 mm long), rarely naked. Lamellae crowded, narrow, 2-3.5 mm broad, concolorous with the pileus or darker, shortly decurrent, with many tiers of lamellulae, brownish-orange (7C7) when dry.

Spores deposit not known. Basidiospores (from gill) [380/14/9] (5.8-) 6.5-8.0(-8.5) × (5.7-)6.0-7.3(-8.3) µm [Q = (1.00-)1.03-1.17(-1.27), **Q** = 1.09

± 0.04] (Holotype: [50/1/1] (6.0-) 6.4-8.0 × (5.7-)6.0-7.0(-7.5) µm [Q = (1.03-)1.05-1.17(-1.27), **Q** = 1.11 ± 0.05]), globose, subglobose to broadly ellipsoid, ornamentation amyloid, composed of ridges and warts, in the form of a broken to nearly complete reticulum with occasional isolated elements in addition, prominences up to 1 µm high. Basidia (30-)35-45 × 11.0-13.0 (-15.0) µm, (2)4-spored, sterigmata 3-7 µm long. Pleurocystidia: macrocystidia (40-)50-75 × 6.0-8.0 (-9.0) µm, lanceolate, acute, scattered, projecting 10-30 µm beyond basidia, often hyaline, rarely with granular contents or refractive masses, pseudocystidia very rare, filamentous, 3-4 µm thick. Cheilocystidia as reduced basidioles, 12-15 × 3-9 µm. Gill trama filamentose, lacking rosettes, lactifers conspicuous. Pileus trama of interwoven hyphae, 4-22.5 µm, most 6-12.5 µm wide, occasionally with scattered sphaerocysts, rosettes absent to poorly differentiated. Pileipellis a layer or zone of globose to subglobose inflated cells, up to 35 µm in diam., mostly 15-25 µm in diam., 3-4 layers, terminal elements stubby-cylindric, 10-20 × 6-8 µm, not regularly anticlinally arranged, dry, no hyphal incrustations observed. Cortex of stipe lacking rosettes. Stipitipellis of longitudinal inflated hyphae, 4-15 µm thick, thin-walled, densely packed, terminal elements scattered, stubby-cylindric or cylindric, 4-7 µm thick, parallel with stipe surface. Hairs at the stipe base composed of un-inflated parallel hyphae, 2-3 µm thick, compactly arranged, rarely branched, septate.



Lactarius hirtipes (HKAS 38819).
Fig. 14. Section through stipitipellis
(right side - stipe surface)

Habit and Habitat: Solitary, very common under Fagaceae (*Castanopsis*, *Quercus*) or *Picea* & *Rhododendron* mixed forest during summer.

Holotype: Yunnan: Binchuan, Jizushan, 6. VIII. 1989, Y. Li & Y. C. Zong 120 (HMAS 57956)

Additional material: Yunnan: Wuding, Changchongshan, 2100 m, 12. VIII. 1999, X. H. Wang 749 (HKAS 38814); Jianchuan, Shibaoshan, 2200 m, 19. VIII. 1999, X. H. Wang 852 (HKAS 38815); Jianchuan, Shibaoshan, 2200 m, 20. VIII. 1999, X. H. Wang 881 (HKAS 38816); Kunming Botanical Garden, 1900 m, 9. VII. 2000, X. H. Wang 1013 (A) (HKAS 38818); Binchuan, Jizushan, 2150 m, 15. VII. 2001, X. H. Wang 1243 (B) (HKAS 38819); Lijiang, Laojunshan, 3400 m, 27. VIII. 2001, X. H. Wang 1282 (HKAS 38820); Qujing, Zhanyi, Zhujiangyuan, Maxiongshan, 2150 m, 23. VIII. 2001, X. H. Wang 1348 (HKAS 38821); Jianchuan, Shibaoshan, 2400 m, 11. IX. 2001, X. H. Wang 1406 (HKAS 38822). **Fujian:** Wuyishan, Huanggangshan, 1640 m, 27. VI. 2001, Y. Liu 010626020.

Observation: The holotype consists of 9 fruiting bodies in good condition and macroscopic characters are easy to observe. It is obvious that rosettes are absent from the stipe cortex and the pileus trama.

Ying (1991) stated that *L. hirtipes* was easily recognized by the white lamellae with cinnamoneus spots and fruiting bodies with fragrant odor. However, such odor could not be detected on the recently collected material. If present at all, it will not be strong. The lamellae are concolorous or sub-concolorous with the pileus, not white. In dry condition, they become ochraceous (7C7) (concolorous with the pileus).

The latex of *L. hirtipes* is usually milk-white at first then changes whey-like. However several fruiting bodies exuding whey-like latex at first were collected at exactly the same forest as those exuding milk-white then whey-like latex. The context and latex are mild to somewhat acrid, depending on different collections.

As *L. chichuensis*, *L. hirtipes* belongs to subgen. *Russularia* sect. *Theiogali* because of the cellular pileipellis. Lacking rosettes in stipe cortex and pileus trama, *L. hirtipes* is very close to three North American species, *L. subserifluus* Longyear, *L. rufulus* Peck and *L. thiersii* Hesler et A.H. Sm. (see Hesler & Smith, 1979: 502-513). The four species can be distinguished according to the following key:

1 Pileus with reddish tinge, reddish brown to orange-ferruginous------------------------2
1' Pileus cinnamon to ochraceous-tawny, pileus cuticle poorly delimited------*L. thiersii*
    2 Macrocystidia absent --3
    2' Macrocystidia present, lanceolate; Pileipellis sharply delimited from the pileus trama; Spores smaller, (5.7-)6.0-7.3 (-8.3) × (5.8-)6.5-8.0(-8.5) µm --*L. hirtipes*

3 Pileus reddish brown, spores larger, 7-9.5× 7-9.5 µm------------------------*L. rufulus*

3' Pileus orange-ferruginous, spores smaller, 6-7.5× 6-7 µm--------------*L. subserifluus*

Comparison: The small and reddish-brown basidiocarps, the glabrous pileus and their habitat and distribution make it difficult to distinguish *L. chichuensis* and *L. hirtipes* in the field. During our study, often in exactly the same forest, the two species were found abundant. Without careful comparison, the specimens could easily be regarded as belonging to the same species. However, the microscopic differences are rather obvious. Microscopic and some subtle macroscopic differences between them are listed in Tab. I.

Both *L. chichuensis* and *L. hirtipes* are common in Yunnan under Fagaceae forest and were also found in Fujian, Southeast China. It is supposed that the distributions of the two taxa are much broader than those known now. *L. camphoratus* reported from Yunnan market by Wang (2000) is actually *L. chichuensis*.

Tab. I. Differences between *L. chichuensis* and *L. hirtipes*

	L. chichuensis	*L. hirtipes*
Spores	zebroid	partially to almost completely reticulate
Stipe cortex	with rosettes	rosettes absent
Pileus trama	with rosettes	rosettes absent
Macrocystidia	larger and conspicuous, often with refractive masses	thinner and not very conspicuous, often hyaline
Pseudocystidia	scattered, often forking	rare
Basidiocarps	stipe long compared with the pileus	stipe short compared with the pileus
Stipe base	strigose hairs longer and noticeable	strigose hairs shorter and often almost naked
Latex	first mild then acrid	mild to acrid
Dry lamellae	brown	brownish orange

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NEW SPECIES OF THE GENUS LEMBOSIA FROM CHINA*

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ABSTRACT

Lembosia brediicola parasitic on *Bredia sinensis*, *Lembosia dalbergiicola* parasitic on *Dalbergia odorifera*, *Lembosia luodingensis* parasitic on Lauraceae indet., and *Lembosia ormosiicola* parasitic on *Ormosia emarginata* are described and illustrated as new species.

Key words: *Lembosia brediicola, Lembosia dalbergiicola, Lembosia luodingensis, Lembosia ormosiicola.*

The genus *Lembosia* was proposed by Léveille in 1845, its type being *Lembosia melastomatum* Mont.(Müller & Arx, 1962; Hosagoudar *et al.*,2001). This is a larger genus in the family Asterinaceae, having superficial mycelium with lateral appressoria, ascomata elongated, ellipsoidal, linear with radiate cells, scattered, non ostiolate, opening by a rupture; conidia absent; non setose; asci ovate to globose with 4-8 ascospores; ascospores 1-septate, brown. Theissen (1913) monographed the genus *Lembosia* with the known species and accounted for 50 species. Stevens & Ryan (1939) gave an account of 56 species. Doidge (1942) described four species of this group for South Africa by segregating species based on the hosts. Müller & Arx (1962) reported five species. Mibey & Hawksworth (1997) reported 18 species from Kenya. Kirk et al. (2001) stated that the genus *Lembosia* contains 40 species, and considered *Heraldoa* Bat., *Lembosidium* Speg., *Lembosiellina* Bat. et Maia, *Micrographa* Müll. et Arg., *Micrographomyces* Cif. & Tomas., and *Morenoella* Speg. synonymous to the genus *Lembosia*. Up to now, 4 species of *Lembosia* have been recorded from China (Yamamoto, 1961; Ouyang, Song & Hu, 1995, 1997).

The authors had obtained specimens of asterinaceous fungi deposited in the Herbarium of Guangdong Institute of Microbiology (HMIGD), Guangzhou (China). Of these, four species are described and illustrated as new species.

Lembosia brediicola sp. nov. (Fig. 1)
Coloniae epiphyllae, atrae, tenuae, arachnoideae vel subvelutinae, ad 3 mm diam. Hyphae atrobrunneae, subrectae vel leniter sinuoae, opposite vel irregulars acuteque vel wideque ramosae, laxe vel dense reticulatae, cellulis 25-45x2.5-3.5 µm. Appressoria unicellula, alternata vel unilatera, antrorsa, recta vel curvula, subglobosa, lobata vel raro integra, 5-8x5-7.5 µm.

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* This project was supported by the Natural Science Foundation of Guangdong (20000205; 020470), and the Foundation of Guangdong Institute of Microbiology, and the Guangdong Provincial Laboratory of Microbial Culture Collection and Application.

loosely to closely reticulate, cells 25-45x2.5-3.5 µm. Appressoria unicellular, alternate or unilateral, spreading, straight or bent, nearly globose, lobate vel rarely entire,5-8x5-7.5 µm. Ascomata black, ellipsoid or oval, elongated, scattered, rarely connate, 110-180x140-280 µm, stellately to longitudinally dehisced at the centre, margin crenate to fimbriate, fringed hyphae straight, closely aggregated and parallel, long; ascospores brown, oblong, 1-septate, obtuse, constricted at septum, surface echinulate, 15-25x9-10 µm.

Holotype: on leaves of *Bredia sinensis* (Diels) H. L. Li (Melastomataceae). Fengyangshan, Zhejiang Province, China. June 25,1991, Y. S. Ouyang HMIGD 31952.

Etymology: *brediicola*, in reference to the host, *Bredia sinensis*.

The host of this species is new record of the genus *Lembosia*.
Nearly globose, lobate to rarely entire of appressoria and surface echinulate of ascospores distinguishes this species from other *Lembosia* species reported on members of the family Melastomataceae.

Lembosia dalbergiicola B. Song, sp. nov. (Fig. 2)

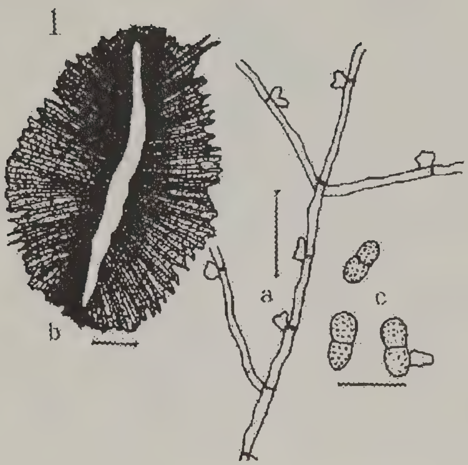
Coloniae epiphyllae, atrae, tenuae, arachnoideae vel subvelutinae, ad 3.6 mm diam.. Hyphae atro-brunneae, plerumque leniter curvae, opposite vel irregulares acuteque vel wideque ramosae, laxe vel dense reticulatae, cellulis 13-23x3-4 µm. Appressoria unicellula, alternata vel unilatera, ad 1% opposita, antrorsa, recta vel subcurvula, cylindracea vel oblonga, obtusa vel subacuta, integra, raro angula, 5.3-9x3-4.3 µm. Ascomata atra, ellipsoidea vel ovala et elongata, dispersa, raro connata, 100-140x250-310 µm, stellato vel longitudinalia dehiscentes ad centro, irregulariter margina crenata vel fimbriata, hypha fringiora recta, compacta et parallela, longiora; ascosporae atro-brunneae, ovata vel ellipsoidea, 1-septatae, obtusae, constrictae, laevis, 15-20x7.5-8 µm.

Colonies epiphyllous, black, thin, arachnoid to nearly velvety, up to 3.6 mm in diameter. Hyphae brown, mostly slightly curved, opposite or irregular branching acutely or obtusely, loosely to closely reticulate, cells 13-23x3-4 µm. Appressoria unicellular, in alternate or unilaternal arrangement, less 1% opposite, spreading, straight or slight curved, cylindric to oblong, obtuse or nearly acute at apex, entire, 5.3-9x3-4.3 µm. Ascomata black, ellipsoid or oval to elongated, scattered, rarely connate, 100-140x250-310 µm, stellately to longitudinally dehisced at the centre, irregular margin crenate to fimbriate, fringed hyphae straight, closely aggregated and parallel, long; ascospores brown, ovate or ellipsoidea, 1-septate, obtuse, constricted at septum, surface smooth, 15-20x7.5-8 µm.

Holotype: on leaves of *Dalbergia odorifera* T. Chen.(Papilionaceae). Xiaohu, Fujian Province, China. August 30, 1987, Y. X. Hu HMIGD 34313.

Etymology: *dalbergiicola*, in reference to the host, *Dalbergia odorifera*.

Cylindrical to oblong and mostly entire of appressoria and surface smooth of ascospores distinguishes this species from other *Lembosia* species reported on members of the family Papilionaceae.



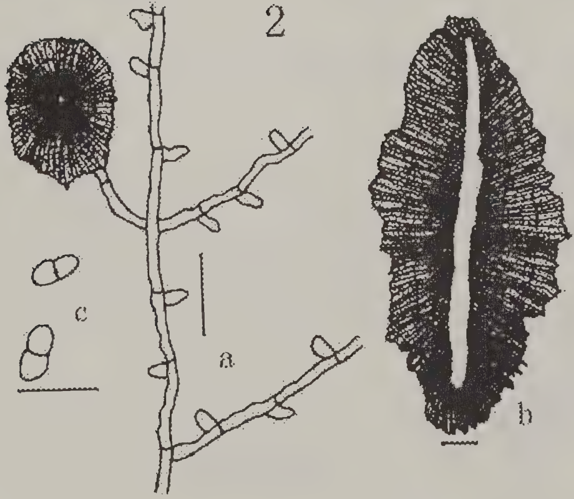


Fig. 1. *Lembosia brediicola:* a.hyphae with appressoria; b. ascomata; c.ascospores (Bars=25μm)
Fig. 2. *Lembosia dalbergiicola* B. Song: a. hyphae with immature ascomata and appressoria; b. ascomata; c.ascospores (Bars=25μm)

Lembosia luodingensis B. Song, sp. nov. (Fig. 3)
Asterina linderae auct. non Hansf.: Ouyang, Song & Hu, *Journ. Trop. Subtrop. Bot.* 5(2):44. 1997.

Coloniae epiphyllae, atrae, tenuae, arachnoideae vel velutinae, ad 3 mm diam. Hyphae atro-brunneae, plerumque plus curvae, opposite acuteque vel wideque ramosae, laxe vel dense reticulatae, cellulis 15-28x5-5.5 µm. Appressoria unicellula, alternata vel unilatera, ad 1% opposita, antrorsa, cylindracea vel conoidea, rotunda vel subacuta, integra, 10-18x5-7 µm. Ascomata atra, suborbicularia vel ellipsoidea et elongata, dispersa vel laxe aggregata, 100-200x80-100 µm, stellato vel longitudinalia dehiscentes ad centro, irregulariter margina crenata vel fimbriata, hypha fringiora recta, compacta et parallela, longiora; ascosporae atro-brunneae, oblongae, 1-septatae, obtusae, constrictae, laevis, 16-22.5x7-10 µm.

Colonies epiphyllous, black, thin, arachnoid to velvety, up to 3 mm in diameter. Hyphae brown, mostly slightly curved, opposite branching acutely or obtusely, loosely to closely reticulate, cells 15-28x5-5.5 µm. Appressoria unicellular, in alternate or unilateral arrangement, less 1% opposite, spreading, cylindrical to conoid, rounded or nearly acute at the apex, entire, 10-18x5-7 µm. Ascomata black, nearly orbicular to ellipsoid, elongate, scattered or loosely aggregate, 100-200x80-100 µm, stellately to longitudinally dehisced at the centre, irregular margin crenate to fimbriate, fringed hyphae straight, closely aggregated and parallel, long; ascospores brown, oblong, 1-septate, obtuse, constricted at septum, surface smooth, 16-22.5x7-10 µm.

Holotype: on leaves of Lauraceae indet.. Luoding county, Guangdong Province, China. Nov. 16,1987, H. Hu HMIGD 34115.

Etymology: *luodingensis*, in reference to the locality from which the speciemens were collected.

Ascospores wall smooth and hyphopodia alternate distinguishes this species from other *Lembosia* species reported on members of the family Lauraceae.

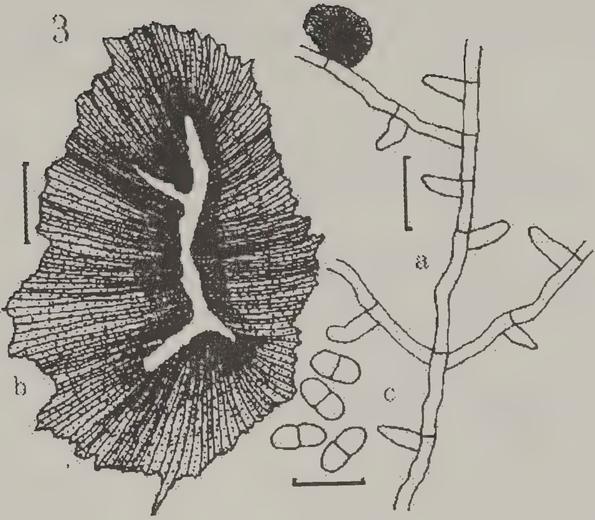
Lembosia ormosiicola B. Song, sp. nov. (Fig. 4)

Coloniae epiphyllae, atrae, tenuae, arachnoideae vel subvelutinae, ad 2 mm diam.. Hyphae atro-brunneae, plerumque plus rectae, opposite vel irregulars acuteque vel wideque ramosae, laxe vel dense reticulatae, cellulis 17-23x3-4 µm. Appressoria unicellula, alternata vel unilatera, ad 1% opposita, antrorsa, recta vel subrecta, cylindracea, obtuse vel subacuta et apice, integra, 7-12x3-4 µm. Ascomata atra, suborbiculata vel hemisphaeria, et elongata, dispersa vel laxe aggregata, 120-300x80-100 µm, stellato vel longitudinalia dehiscentes ad centro, irregulariter margina crenata vel fimbriata, hypha fringiora recta, compacta et parallela, longiora; ascosporae atro-brunneae, cylindraceae, 1-septatae, obtusae, constrictae, echinulatae, 22-37x7.5-10 µm.

Colonies epiphyllous, black, thin, arachnoid to nearly velvety, up to 2 mm in diameter. Hyphae brown, mostly slightly straight, opposite or irregular branching acutely or obtusely, loosely to closely reticulate, cells 17-23x3-4 µm. Appressoria unicellular, alternate or unilaternal, less 1% opposite, spreading, straight or slight curved, cylindrical, obtuse or nearly acute at apex, entire, 7-12x3-4 µm. Ascomata black, nearly orbicular or hemispherical, elongate, scattered to loosely aggregate, 120-300x80-100 µm, stellately to longitudinally dehisced at the centre, irregular margin crenate to fimbriate, fringed hyphae straight, closely aggregated and parallel, long; ascospores brown, cylindrical, 1-septate, obtuse, constricted at septum, surface verrucose, 22-37x7.5-10 µm.

Holotype: on leaves of *Ormosia emarginata* (Hook. et Arn.) Benth.(Papilionaceae). Nankunshan, Guangdong Province, China. Sept.16,1992, Y. S. Ouyang et B. Song HMIGD 34314.

Etymology: *ormosiicola*, in reference to the host, *Ormosia emarginata.*



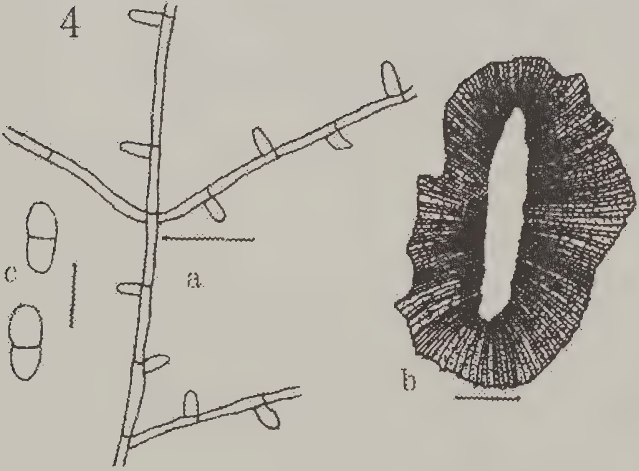


Fig. 3. *Lembosia luodingensis* B. Song (a.hyphae with immature ascomata and appressoria; b. ascomata; c.ascospores). (Bars=25μm)

Fig. 4. *Lembosia ormosiicola* B. Song (a.hyphae with appressoria; b.ascomata; c.ascospores). (Bars=25μm)

The new species is closely related to *Lembosia dalbergiicola* B. Song. The distinguishing character of *L. dalbergiicola* is that the ascospores are smaller (15-20x7.5-8 μm for ascospores) and surface verrucose.

ACKNOWLEDGEMENTS

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NEW SPECIES OF THE GENUS ASTERINA FROM CHINA[*]

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ABSTRACT

Asterina hodgsoniae parasitic on *Hodgsonia macrocarpa* var. *capniocarpa*, *Asterina lawsoniicola* parasitic on *Lawsonia inermis*, *Asterina pentaphylacis* parasitic on *Pentaphylax euryoides*, and *Asterina rogergoosii* on *Turpinia pomifera* are described and illustrated as new species.

Key words: *Asterina hodgsoniae*, *Asterina lawsoniicola*, *Asterina pentaphylacis*, *Asterina rogergoosii*.

Asterina Lév. is the largest genus of the family Asterinaceae. This genus differs from other genera of Asterinaceae in having appressoria on the mycelium and lacks setae on the ascomata or hyphae, ascospores 2-celled (Hansford, 1946; Hosagoudar *et al.*, 2001). Over 578 species of the genus *Asterina* have been described and over 85 species have been reported from China (Kirk *et al.*, 2001; Hosagoudar & Abraham, 2000; Ouyang *et al.*, 1995,1996,1997; Song *et al.*, 1996, 2001, 2002).

The authors obtained specimens of asterinaceous fungi deposited in the Herbarium of Guangdong Institute of Microbiology (HMIGD), Guangzhou (China). Of these, four species are described and illustrated as new species.

Asterina hodgsoniae sp. nov. (Fig. 1)

Coloniae epiphyllae, atrae, tenuae, arachnoideae vel subvelutinae, ad 2 mm diam. Hyphae atro-brunneae, subrectae, opposite acuteque vel wideque ramosae, laxe vel dense reticulatae, cellulis 30-40x3.5-5μm. Appressoria unicellula, alternata vel unilatera, antrorsa, plerumque recta, subglobosa, lobula vel angulata, 7.5-10(-12.5)x8-10 μm. Ascomata dispersa vel laxe aggregata, atra, orbiculata vel hemisphaeria, ad 150 μm diam., margina crenata vel fimbriata, stellate dehiscentia ad centrum; ascosporae atro-brunneae, oblongae, 1-septatae, obtusae, constrictae, laevis, 30-32x8-10 μm.

Colonies epiphyllous, black, thin, arachnoid or nearly velvety, up to 2 mm in diameter. Hyphae brown, nearly straight, opposite branching acutely or obtusely, loosely to closely reticulate, cells 30-40x3.5-5 μm. Appressoria unicellular, alternate to unilateral, spreading, mostly straight,

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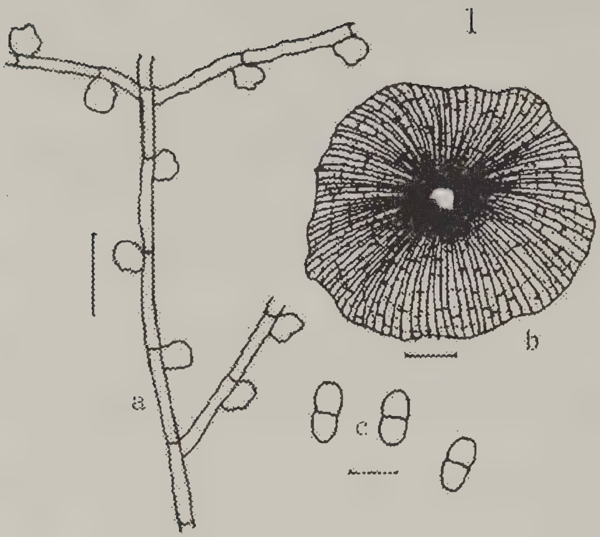
[*] This project was supported by the Natural Science Foundation of Guangdong (20000205; 020470), and the Foundation of Guangdong Institute of Microbiology, and the Guangdong Provincial Laboratory of Microbial Culture Collection and Application.



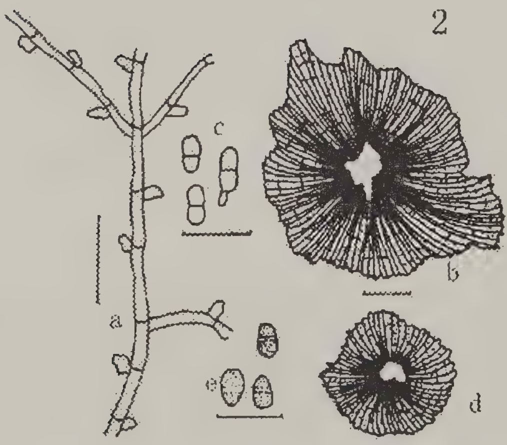


Fig. 1. *Asterina hodgsoniae*: a.hyphae with appressoria; b. ascomata; c. ascospores (Bars=25μm)
Fig. 2. *Asterina lawsoniicola* B. Song: a. hyphae with appressoria; b. ascomata; c. ascospores; d. pycnidium; e. conidium (Bars=25μm)

nearly globose, lobate or angled, 7.5-10(-12.5)x8-10 µm. Ascomata scattered to loosely aggregate, black, orbicular or hemispherical, up to 150 µm in diameter, margin crenate to fimbriate, dehiscing stellately at the centre; ascospores brown, oblong, 1-septate, obtuse, constricted at septum, surface smooth, 30-32x8-10 µm.

Holotype: on leaves of *Hodgsonia macrocarpa* (Bl.) Cogn. var. *capniocarpa* (Rild.) Tsai (Cucurbitaceae). Mengla, Yunnan Province, China. July 31, 1985, Y. X. Hu HMIGD 34167.

Etymology: *hodgsoniae*, in reference to the host species, *Hodgsonia macrocarpa* var. *capniocarpa*.

The present species is closely related to *Asterina momordicae* Yates. The distinguishing character of *A. momordicae* is that the size of ascospores is smaller (19-21x9-11 µm)(Yates, 1918).

Asterina lawsoniicola B. Song, sp. nov. (Fig. 2)

Coloniae amphigenae, atrae, tenuae, arachnoideae vel subvelutinae, ad 2 mm diam. raro confluentes. Hyphae atro-brunneae, subrectae vel subcurvae, alternate vel opposite et acuteque vel wideque ramosae, laxe vel dense reticulatae, cellulis 15-40x3-4.2 µm. Appressoria unicellula, alternata vel unilatera, antrorsa, cylindracea vel conica, lobula, raro integra, 5-8x3-7 µm. Ascomata dispersa vel laxe aggregata, atra, orbiculata vel hemisphaeria, ad 150 µm diam., margina crenata vel fimbriata, stellate dehiscentia ad centrum; ascosporae atro-brunneae, oblongae, 1-septatae, obtusae, constrictae, laevis, 15-17x5.5-8 µm. Pycnidia dispersa, hemisphaeria, margina crenata vel fimbriata, stellate dehiscentia ad centrum, ad 110 µm diam.; conidiae unicellulae, ovatae, atro-brunneae, in medio zona hyaline praeditae, 12.5-16x5.5-8 µm.

Colonies amphigenous, black, thin, arachnoid to nearly velvety, up to 2 mm in diameter, rarely confluent. Hyphae brown, nearly straight to nearly curved, alternate or opposite branching acutely or obtusely, loosely to closely reticulate, cell 15-40x3-4.2 µm. Appressoria unicellular, alternate to unilateral, spreading, cylindrical or conoidal, lobe, rarely entire, 5-8x3-7 µm. Ascomata scattered to loosely aggregate, black, orbicular to hemispherical, up to 150 µm in diameter, margin crenate to fimbriate, dehiscing stellately at the centre; ascospores brown, oblong, 1-septate, obtuse, constricted at septum, surface smooth, 15-17x5.5-8 µm. Pycnidia scattered, hemispherical, margin crenate to fimbriate, dehiscing stellately at the centre, up to 110 µm in diameter; conidia unicellular, ovate, brown, with hyaline zone in median, 12.5-16x5.5-8 µm.

Holotype: on leaves of *Lawsonia inermis* Linn (Lythraceae). Hainan Province, China. June 18,1984, Y. X. Hu HMIGD 34153.

Etymology: *lawsoniicola*, in reference to the host species, *Lawsonia inermis*.

The present species is closely related to *Asterina lawsoniae* P. Henn. & E. Nym. known on the family Lythraceae. The distinguishing character of *A. lawsoniae* is that the ascospores are longer (17-20x6.5-8 µm) and surface echinulate (Theissen, 1913).

Asterina pentaphylacis B. Song, sp. nov. (Fig. 3)

Coloniae amphigenae, plerumque epiphyllae, atrae, tenuae, arachnoideae vel velutinae, ad 2.5 mm diam. raro confluentes. Hyphae atro-brunneae, rectae vel curvae, opposite vel irregularly acuteque vel wideque ramosae, laxe vel dense reticulatae, cellulis 20-40x5-6 µm. Appressoria unicellula, alternata vel unilatera, antrorsa, ovata vel subglobosa, angulata vel sublobula, raro integra, 9-13x8-12 µm. Ascomata dispersa vel laxe aggregata, atra, orbiculata vel hemisphaeria, ad 170 µm diam., margina crenata vel fimbriata, stellate dehiscentia ad centrum; ascosporae atro-brunneae, suboblongae, 1-septatae, obtusae, constrictae, laevis, 16-25x7.5-10 µm.

Colonies amphigenous, mostly epiphyllous, black, thin, arachnoid to velvety, up to 2.5 mm in diameter, rarely confluent. Hyphae brown, straight to curved, opposite to irregular branching acutely or widely, loosely to closely reticulate, cells 20-40x5-6 µm. Appressoria unicellular, in alternate or unilateral arrangement, spreading, ovate to nearly globose, angulose to sublobed, rarely entire, 9-13x8-12 µm. Ascomata scattered to loosely aggregate, black, orbicular to hemispherical, up to 170 µm in diameter, crenate to tasseled at periphery, stellately dehiscent at central; ascospores brown, nearly oblong, 1-septate, obtuse at ends, constricted at septum, surface smooth, 16-25x7.5-10 µm.

Holotype: on leaves of *Pentaphylax euryoides* Gardn. & Champ. (Pentaphylacaceae). Ruyang, Guangdong Province, China. August, 1985, H. Hu *et al.* HMIGD 34183; Diaoloushan, Hainan Province, China. May 28, 1988, Y. X. Hu HMIGD 30340 (Isotype).

Etymology: *pentaphylacis*, in reference to the host species, *Pentaphylax euryoides*.

The present species is the first record of the genus *Asterina* on the family Pentaphylacaceae (Hosagoudar *et al.* 2000), and it is found mixed with *Meliola pentaphylacis* B. Song et Y.X. Hu.

Asterina rogergoosii B. Song, sp. nov. (Fig. 4)

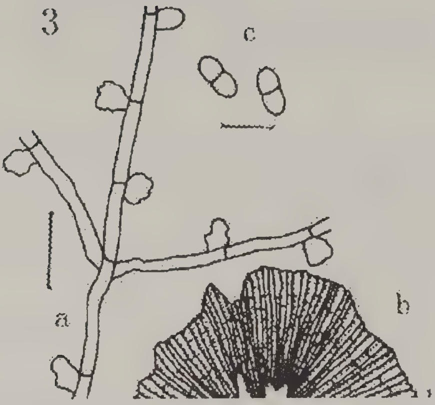
Coloniae hypophyllae, atrae, tenuae vel subdensae, arachnoideae vel subvelutinae, dispersae, ad 9 mm diam. raro confluentes. Hyphae atro-brunneae, sinuosae vel undulatae, irregularly acuteque vel wideque ramosae, laxe vel dense reticulatae, cellulis 25-45x2.5-3.8 µm. Appressoria bicellula, alternata vel unilatera, antrorsa, plermuque sinuosa, 13-18 µm longa; cellulae basilares cylindraceae vel cuneatae, 3-6 µm longae; cellulae apicales cylindraceae vel clavatae, angulosae vel 1-3-lobulae, 10-14x5-15 µm. Ascomata dispersa vel laxe aggregata, atra, orbiculata vel hemisphaeria, ad 130 µm diam., margina crenata vel fimbriata, stellate dehiscentia ad centrum; ascosporae oblongae-ellipsoideae, atro-brunneae, 1-septatae, obtusae, constrictae, laevis, 17-33x8-13 µm. Pycnidia pauca, atra, dispersa, hemisphaeria, stellate dehiscentia ad centrum, crenata at peripheria, ad 100 µm diam.; conidia unicellula, atro-brunnea, in medio zona hyaline praedita, ovato-ellipsoidea, obtusa, 11-17x7-10 µm.

Colonies hypophyllous, black, thin to subdense, arachnoid to nearly velvety, scattered, up to 9 mm in diameter, rarely confluent. Hyphae brown, sinuous to undulate, irregularly branching at acutely or obtusely, loosely to closely reticulate, cells 25-45x2.5-3.8 µm. Appressoria bicellular, in alternate or unilateral arrangement, spreading, mostly bent, 13-18 µm long; stalk cells cylindrical or cuneate, 3-6 µm long; head cells cylindrical to clavated, spreading, angular or 1-3-lobate, 10-14x5-15 µm. Ascomata scattered to loosely aggregate, black, orbicular or hemispherical, up to 130 µm in diameter, margin crenate to shortly fringed, stellately dehisced at the centre; ascospores oblong-ellipsoidea, brown, 1-septate, obtuse, constricted at septa, surface smooth, 17-33x8-13 µm. Pycnidia few, black, scattered, hemispherical, stellately dehisced at the centre, crenate at periphery, up to 100 µm in diameter; conidia unicellular, brown, with hyaline zone in median, ovate-ellipsoid, obtuse, 11-17x7-10 µm.

Holotype: on leaves of *Turpinia pomifera* (Roxb.) DC. (Staphyleaceae). Fanjingshan, Guizhou Province, China. May 14, 1991, Y. S. Ouyang HMIGD 31995.

Etymology: this species is named in honour of the Prof. Dr. Roger D. Goos for the contribution towards the study of the Asterinaceae.

The present species is the first record of the genus *Asterina* on the family Staphyleaceae (Hosagoudar *et al.* 2000) and it is found mixed with *Asteridiella tapisciicola* H. Hu.



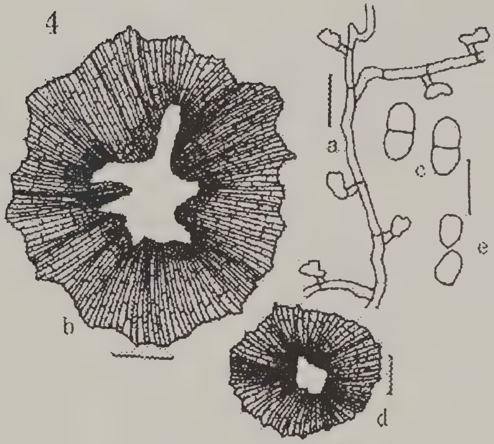


Fig. 3. *Asterina pentaphylacis* B. Song: a. hyphae with appressoria; b. ascomata; c. ascospores (Bars=25μm)

Fig. 4. *Asterina rogergoosii* B. Song: a. hyphae with appressoria; b. ascomata; c. ascospores; d. pycnidium; e. conidium (Bars=25μm)

ACKNOWLEDGEMENTS

We are deeply grateful to Dr. R. D. Goos of Department of Botany, University of Rhode Island (U.S.A.) for reviewing the manuscript. We especially acknowledge Prof. Y.S. Ouyang, Mr. Y. H. Shen, and Mrs. A.L. Zhang for their various helps.

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TAXONOMY AND PATHOLOGY OF MACROSPORA//NIMBYA ON SOME NORTH AMERICAN BULRUSHES (SCIRPUS SPP.)

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ABSTRACT

Isolates of *Nimbya* species were obtained from diseased culms of *Scirpus acutus* and *S. validus* from several locations in the Pacific Northwest and Minnesota, USA. Ascomata with ascospores of two *Macrospora* species formed on autoclaved segments of *Scirpus* stems in axenic culture when inoculated with conidia of two *Nimbya* species. Single ascospores yielded cultures of the respective *Nimbya* species. The taxa were demonstrated to be homothallic; isolates were pathogenic to *S. acutus* and *S. validus*. On the basis of morphological characterization, some of the isolates from *S. acutus* warrant descriptions as new species: *Macrospora scirpinfestans* (anamorph *Nimbya scirpinfestans*) and *M. scirpivora* (anamorph *N. scirpivora*).

Keywords: aquatic habitat, homothallic Ascomycetes

INTRODUCTION

Bulrushes of the genus *Scirpus* constitute an integral component of the ecosystem in many lakes, rivers, marshes, and other wet places. Among other functions, they provide cover and secondary food for songbirds and waterfowl, reduce erosion along banks, and play a primary role in plant succession. Negatively, they may impede water flow in irrigation ditches. Several fungi have been observed on and isolated from *Scirpus* spp. (Farr et al., 1989), but little is known concerning their ecology.

Conidium isolates of *Nimbya* Simmons (1989) were made from the margins of lesions on *Scirpus validus* Vahl growing in lakes in Minnesota and from *S. acutus* Muhl. from lakes and rivers in the Pacific Northwest. Mature ascomata of *Macrospora* species (Fuckel 1870) formed in diseased culms of *S. validus* and *S. acutus* after surface disinfection, inoculation from isolates, and incubation of culm sections on moistened filter paper in petri dishes in the laboratory. These observations initiated further studies on the relationship of *Macrospora* and *Nimbya* and their relationship with *Scirpus* spp.

This *Introduction*, *Material and Methods*, *Pathogenicity* and single ascospore studies cover the activity of authors D.A.J., J.S.M. and E.L.S., who worked with isolates of *Nimbya* made early in the time span of this study. The concluding *Taxonomy* section was prepared by author E.G.S., who worked with only one of the early isolates (DAJ AF-3 from Idaho) but with many isolates made by himself from fresh *Scirpus* specimens supplied by D.A.J. in 2001.

MATERIALS AND METHODS

Diseased culms of *S. validus* were collected from Lake Itasca in northern Minnesota and from lakes near St. Paul, Minnesota, in the summers of 1974 and 1975. Diseased culms of *S. acutus* were collected from the Snake River in southern Idaho and central Washington, from lakes and marshes in eastern and western Washington, British Columbia, western Montana, and Wyoming from 1986 to 2001. Plants were placed in plastic bags, transported to the laboratory, washed with running water, and surface disinfected in a 1% solution of sodium hypochlorite. Tissue samples were plated on potato dextrose agar media. Culm sections approx. 7 cm long were placed on moist filter paper in petri dishes.

Ascomata were produced by seeding conidia of species of *Nimbya* on 2% water agar in petri dishes adjacent to the center of a 7 cm long segment of an autoclaved culm of either *S. acutus* or *S. validus* embedded in the agar. Cultures were then incubated at 15 to 23 C for up to 30 days.

Conidial cultures derived from single ascospores produced in axenic culture were used to determine the sexual compatibility system of the *Macrospora* species. Isolations from diseased plant material of *S. acutus* collected from the Snake River near American Falls, Idaho; lakes near Moses Lake, Spokane, and Issaquah, Washington; and Missoula, Montana, were used to produce pseudothecia on autoclaved culms in water agar. Ten to 15 mono-ascosporal cultures from each of the five locations were selfed and paired in all combinations on water agar containing a segment of a *S. acutus* culm. Cultures were then incubated at 21 C for four weeks.

Plants of *S. validus* that appeared healthy were transported in buckets from their natural habitat in lakes near St. Paul, Minnesota, in 1974 to a greenhouse and transplanted into 21-cm-diam pots. Pots and plants were placed in tanks and submerged in tap water about 5 mm above the level of the soil. Six weeks after transplanting, ten healthy-appearing culms were inoculated by placing *Nimbya* conidia into 5 mm cuts in the culms. Conidia for inoculation were produced on potato dextrose agar. Culms of five plants were used as non-inoculated controls by making a 5 mm cut in the culms. Inoculated culm sections and non-inoculated controls were wrapped with parafilm for five days. In 1986 near Prosser, Washington, ten healthy-appearing culms of *S. acutus* growing along an irrigation canal were inoculated with conidia of a *Nimbya* strain and five culms were used as non-inoculated controls.

PATHOGENICITY

Nimbya isolates were obtained repeatedly from diseased culms of *S. validus* and *S. acutus* collected from Minnesota, Washington, Idaho, Montana, Wyoming and British Columbia. Pseudothecia of *Macrospora* species formed in field specimens of diseased culms of *S. validus* and *S. acutus* placed on moistened filter paper in petri dishes; the *Macrospora* taxa were not identified to species during the early pathogenicity studies.

Lesions on *Scirpus* culms are pale to dark brown or black, circular to irregular in shape, and usually 1-10 mm diam. Some lesions have dark margins; adjacent tissue often is chlorotic. Small lesions usually are circular, light brown to tan, with a dark brown central area. Parenchyma internal to large lesions is necrotic. Lesions coalesce to form blotches; inflorescences frequently are blasted from severe infections near the distal end of the culm. Disease incidence by mid-summer in the Pacific Northwest frequently is greater than 90% for infected culms and often greater than 60% for blasting of inflorescences.

Culms inoculated with conidia developed symptoms similar to those in natural habitats within 10-14 days after inoculation. *Nimbya* reisolates were obtained from these lesions. Non-inoculated culms remained healthy.

Single ascospores of *Macrospora* species yielded pure cultures of *Nimbya* when placed on PDA. Ascomata with ascospores of the *Macrospora* teleomorph developed in autoclaved sections of *Scirpus* culms embedded in agar when seeded with conidia of the anamorph. Ascomata became evident after 15-30 days of incubation at temperatures of 15-23 C. All selfed and paired mono-ascosporial cultures yielded ascomata of the *Macrospora* species.

TAXONOMY

The relationship of *Macrospora* taxa and their *Nimbya* anamorphs was explored by Simmons in 1989, with considerable attention paid to species on *Scirpus, Eleocharis, Juncus,* and *Carex*. However, Simmons emphasized at that time that his treatment of *Macrospora scirpicola* (DC. : Fr.) Fuckel (1870) and *Nimbya scirpicola* (Fuckel) Simmons (1989) was not to be considered the final word on the subject. The reason was that he did not believe that teleomorphs pertinent to the relationships were identifiable with each other. The opinion was based specifically on examination of De Candolle's type of *Sphaeria scirpicola* (1805, on *Scirpus lacustris* L.); of Fuckel's collection of "*S. scirpicola*" that influenced his establishment of *Macrospora scirpicola* (DC.) Fuckel (1870, on *S. lacustris*); and of a John Webster modern collection (EGS 19-016, on *Eleocharis palustris* L.), which, along with the early type material, was discussed as *Macrospora scirpicola*.

Numerous isolates of *Nimbya* from *Scirpus* in the present study support further observations, with the conclusion that all three of the teleomorphs considered in the 1989 study are of different species—and further, that neither of two *Macrospora* taxa isolated in the current study is identifiable with De Candolle's typical *M. scirpicola*. As detailed below, one isolate among the dozens studied represents a distinguishable *Macrospora/Nimbya* species from Idaho material. Three other *Nimbya* isolates from Washington and Wyoming specimens matured as a second distinguishable species of *Macrospora*. Many other isolates (Washington, Colorado) produced abundant conidia distinguishable from those of the two new taxa and from all other described *Nimbya* taxa, but they produced no ascomata under the culture conditions specified below.

It is noted that Lucas and Webster (1964) obtained ascomata of a *Macrospora* taxon in cultures derived from 1-conidium and 1-ascospore isolates, and that they considered the taxon to be homothallic. Their isolates from a species on *Cyperus longus* L. were identified at the time as *Pleospora scirpicola* (DC.) Karsten (1873; ≡ *Macrospora scirpicola*), which is believed not to be the same species as either of the two described in the present study.

Descriptions of new taxa in this *Taxonomy* section are based on isolates derived from single conidia that were studied on potato/carrot agar (20:20:20/liter) and on steam-sterilized segments of *Scirpus* stems placed directly on PCA in petri dishes. Other growth conditions included temperature at ca. 20 C and an 8/16 hr cool-white fluorescent light/dark cycle.

Macrospora scirpinfestans E. G. Simmons & D. A. Johnson, sp. nov.
Fig. 1

Ex conidio Nimbya scirpinfestans in caule sterilifacto Scirpi in agaro PCA culta et descripta. Ascomata brunnea, depresse globosa, ca. 500 x 400µm, apice obtusiconoideo secedente. Asci in juventute late ovoidei, ca. 120 x 70µm; in maturitate late ellipsoidei, aequilateri vel submusiformes, plerumque 8-spori, ca. 150-200 x 50µm. Ascosporae ellipsoideae, applanatae, 45-65(-72) x 18-22 x ca. 15µm, 5-6(-7) transeptatae et in 4(-5) segmentis mediis transversis 1(-2) longiseptatae, subhyalinae, demum dilute flavae, septis fuscatis. Habitatio typi in caule Scirpus sp. in agaro PCA, ex conidio Nimbya scirpinfestans in caule Scirpus acutus Muhl., American Falls, Massacre Rocks State Park, Idaho, oriundo. Typus: pars ex cultura EGS 49-185 (D. A. Johnson AF-3) desiccata et in ***BPI*** *841965 (Holotypus) conservanda.*

Ascomata of *M. scirpinfestans* develop slowly in the outer tissues of sterilized *Scirpus* stem sections placed on PCA. They become visible as solitary, scattered, dark subepidermal dots as early as 2 wks after inoculation with fresh conidia. They mature within 3-4 wks as subspherical pseudothecia ca. 500 x 400µm (w x h) with a blunt-conical apex; these lift and eventually push through the epidermis. The dark apical cell layers constitute a shield-shaped disk filled with hyaline cells. This round cap separates readily from the ascoma body, leaving a round pore through which ascospores are ejected. The presence of such a clypeate structure at the ascoma apex is used by Shoemaker and Babcock (1992) to define the Diademaceae, to which they assign *Macrospora*. The ascoma contains well-defined but only partially septate, subhyaline, immature ascospores at ca. 3 wks; complete septation develops by 4-5 wks, with mature ascospore color a dingy, very dilute yellow and with septa only slightly darker.

Juvenile asci are broadly ovoid, ca. 120 x 70μm; they become broadly ellipsoid and equilateral or curved (depending on proximity to ascocarp wall), commonly but not always 8-spored, 150-200+ x 50+μm when ascospores approach full development. Mature ascospores may be ejected forcibly to at least the height of the petri dish cover (ca. 7 mm above the substrate), where they land in considerable numbers and may germinate and produce conidiophores and conidia.

Fully developed ascospores of *M. scirpinfestans* are larger and more abundantly septate than those of any other species of the genus described to date. Many juvenile ascospores are equilaterally ellipsoid and retain this appearance in one orientation as they enlarge. These spores are slightly constricted at the first three transverse septa; the initial transeptum is median, each of the next two is near a rounded end of the spore. In a different orientation (a 90° turn), the ascospore is seen to be flattened; if the inequilateral tendency has been strong, an ascospore may be curved in the direction of one flattened side. Other juvenile ascospores retain a distinct basal taper as the spore enlarges and produces transepta additional to the initial three. Such spores develop various degrees of unilateral flattening and longitudinal curvature. Transverse septation often reaches 6-7 in ascospores that mature in either pattern, although 5 is a common number. A longitudinal septum is inserted in each transverse segment except for the terminal cells. Occasionally a second longiseptum is formed in 1-3 of the widest transverse segments. Ascospores with at least 5 transepta are 45-65(-72) x 18-22 x ca. 15μm; they are subhyaline throughout most of their septation development and even at the time of release, finally becoming a dilute dull yellow with darker septa.

Typical *M. scirpinfestans* is known at present only as a laboratory derivative (DAJ AF-3) of *Nimbya scirpinfestans* conidia isolated from a *Scirpus acutus* field specimen used in the early pathogenicity studies. Production of ascomata is sparse under laboratory conditions. Details of the original ascoma-productive *Nimbya* field conidia are not known, but the isolate produces enormous numbers of distinctive conidia on PCA and *Scirpus* substrates.

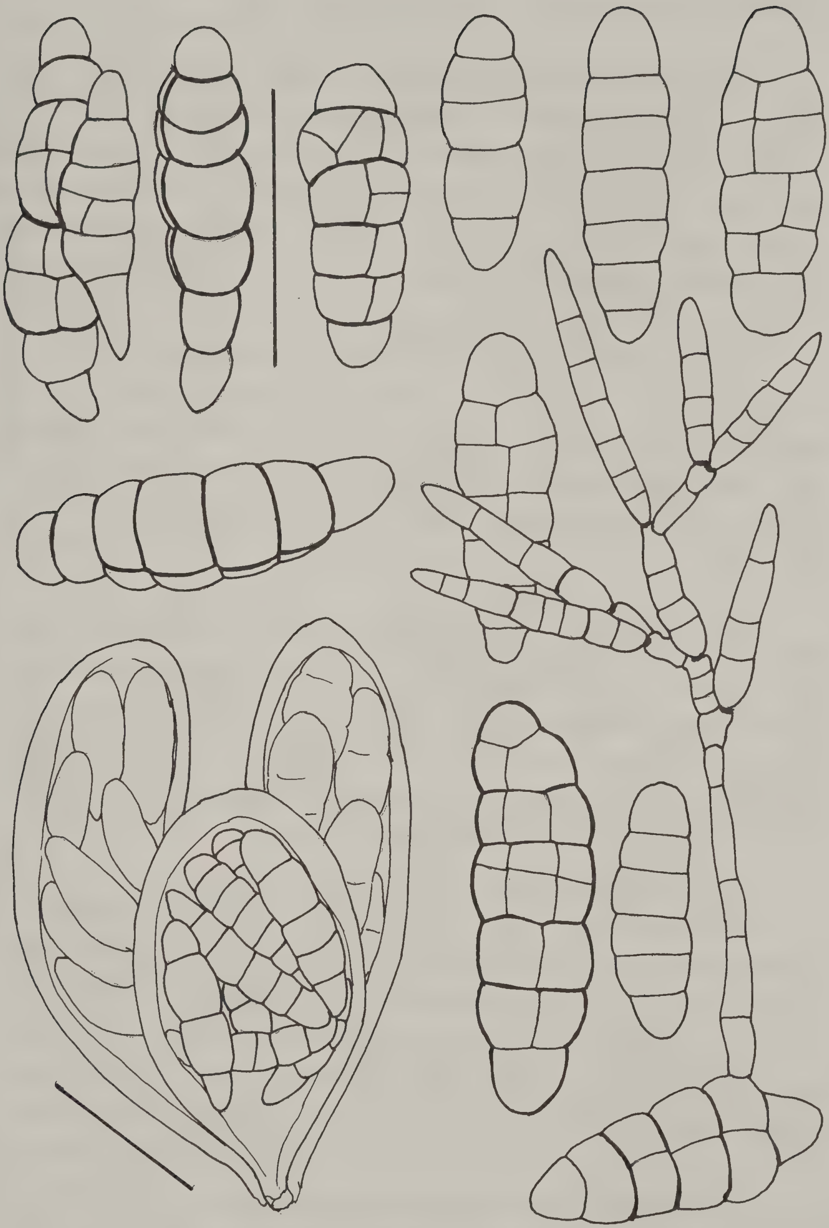

Fig. 1. *Macrospora scirpinfestans* asci, ascospores, and anamorph sporulation from a germinated ascospore. Culture substrate: *Scirpus* stem on PCA. EGS 49-185. Bars = 50μm.

Nimbya scirpinfestans E. G. Simmons & D. A. Johnson, sp. nov. Fig. 2

Ex culturis in agaro PCA descripta. Colonia atra; mycelium coloniae insuper agaro tenuiter effusum et super coloniam in strato macilento, arachnoideo. Conidiophora brevia, simplicia, ca. 10-30 x 3-4μm, locis conidiogenis 1-4; vel longa, ca. 100-150μm angustissima, systemate ramificanti apicali cellularum conidiogenarum; vel brevia, simplicia, plurima, ex pulvinis atris, cellulosis, aeriis ad ca. 65-130μm diam. oriundis. Conidia plerumque solitaria, sed interdum 2-3 catenulata; anguste ovoidea vel anguste ellipsoidea, 30-80 x 4-6μm, subhyalina, 3-8 transverse distoseptata, interdum 1-2 transeptis genuinis insertis; septa longitudinalia ignota. Conidia pro parte minore 90-130 x 6-8μm, subhyalina, 9-13 transverse distoseptata, interdum in uno transepto vero inserto constricta. Habitatio typi in caule Scirpus acutus Muhl., American Falls, Massacre Rocks State Park, Idaho. Typus: partes ex cultura EGS 49-185 ex caule Scirpus acutus, American Falls, Idaho, D. A. Johnson AF-3 lect. et sejunct., desiccatae et in ***BPI*** *841966 (Holotypus) et saltem* ***IMI*** *(isotypus) conservandae.*

Although colonies of *N. scirpinfestans* develop rapidly on PCA and appear dark and dense, there is no appreciable mass of vegetative, non-sporulating mycelium. Instead, colony mycelium spreads thinly within and on the agar surface and over the colony as an open arachnoid layer of delicate hyphae. The perceived density derives from enormous numbers of simple to complex conidiophores and from even greater numbers of narrow, elongate conidia. The conidiophores develop in three different patterns.

Most conidiophores are borne on both surface and aerial hyphae as short hyphal branches ca. 10-30 x 3-4μm with 1-4+ conidiogenous sites terminating geniculate growth extensions. A second type of conidiophore also is very common: long, very narrow erect hyphae 100-150μm or more in length, but scarcely 2μm diam, which expand into an apical complex of branching conidiogenous cells. The conidiogenous cells of these aerial complexes tend to occur in tight, twisted groups; the conidia that arise from such complexes thus appear at 50X as clusters of narrow, divergent spines.

A third striking element of sporulation develops on the thin arachnoid aerial hyphae of the colony as dark irregular masses ca. 100-200μm diam. Each such structure is a compact knot of subglobose cells, many of which protrude as short 1-3-celled conidiophores. Since the conidiogenous structures

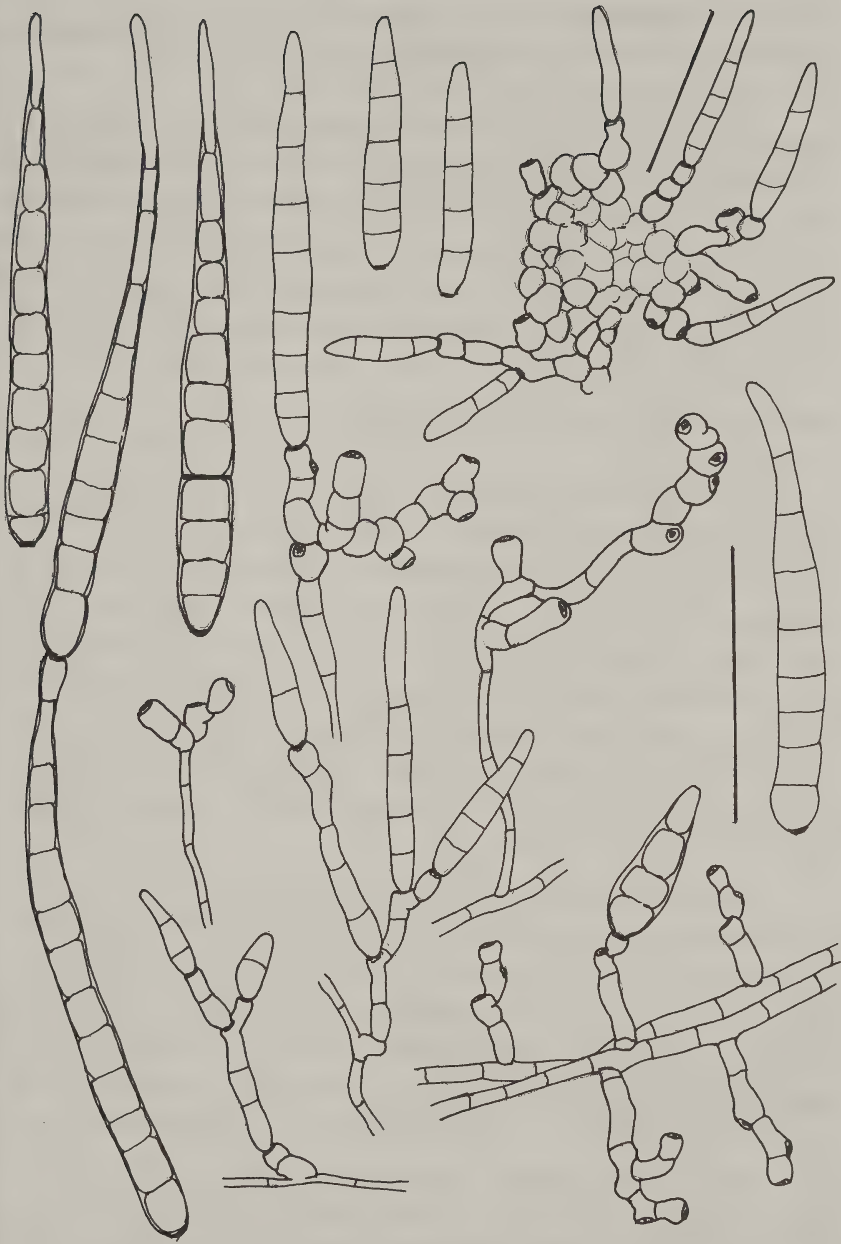

Fig. 2. *Nimbya scirpinfestans* conidia, conidiophore development patterns, and (upper right) a small portion of a densely cellular aerial sporulation mass. Culture substrate: *Scirpus* stem on PCA. EGS 49-185. Bars = 50μm.

develop in all directions from the central clump of cells, the 50X appearance is that of a small, dark, spiny head of long narrow conidia.

Most conidia are solitary, although chains of 2-3 are common. The great bulk of conidia are narrow-ovoid or narrow-ellipsoid with a slight upward taper; 30-80 x 4-6μm, subhyaline, 3-8 transversely distoseptate, occasionally with 1-2 eu-transepta; longitudinal septa have not been found. A minor but common and quite noticeable portion of the conidial population consists of long narrow spores that are 90-130 x 6-8μm, subhyaline, 9-13 transversely distoseptate, and sometimes with a minor wall constriction where a euseptum has formed. These larger conidia may occur in chains of two units.

Macrospora scirpivora E.G. Simmons & D. A. Johnson, sp. nov. Fig. 3

Ex conidio Nimbya scirpivora in caule Scirpus sp. sterilifacto in agaro PCA culta et descripta. Ascomata brunnea, depresse globosa, ca. 380 x 320μm, apice breviconoideo. Asci in maturitate late ellipsoidei, plerumque 8-spori, ca. 160-190 x 40-50μm. Ascosporae in juventute subellipsoideae, 3(-5) transeptatae, septo mediano profunde penitus constrictae; in maturitate late ellipsoideae, parum applanatae, 38-45 x 14-16 x 11-12μm, 5(-6) transeptatae, et in 1-4 segmentis mediis transversis unilongiseptatae, subhyalinae vel demum dilute flavae, septis fuscatis. Habitatio typi in caule Scirpus sp. in agaro PCA, ex conidia Nimbya scirpivora in caule Scirpus acutus Muhl., Douglas, Wyoming, oriundo. Typus: pars ex cultura EGS 50-021 desiccata et in ***BPI*** *841967 (Holotypus) conservanda.*

Ascomata of *M. scirpivora* develop in the outer tissues of sterilized *Scirpus* stem sections placed on PCA. They become visible as solitary, scattered, dark subepidermal dots within 1-2 wks after inoculation with fresh conidia. Mature pseudothecia are subspherical, ca. 380 x 320μm (w x h), with a short conical apex; at this stage they raise the surface cell layers of the host, through which the ascoma apex protrudes. Abundant immature asci are present within 21 d.; ascospores in all stages of development are present within 23 d.

Asci are broadly ellipsoid, equilateral or musiform, commonly but not always 8-spored, ca. 160-190 x 40-50μm when ascospores approach full septation. Juvenile ascospores have a narrow spindle shape and produce an initial median transeptum at this stage. Subsequent development is into a subellipsoid 3-5 transeptate spore deeply constricted at the median septum. Mature ascospores are broadly ellipsoid with 5 transepta (rarely 6) and 1 longitudinal septum in each of 1-4 of the central transverse segments; constriction may remain prominent at the median septum and moderate or minor at other septa. Ascospores viewed in the broadly ellipsoid orientation are equilateral; viewed at a 90° turn, they are slightly to strongly inequilateral and somewhat flat. Ascospores at full development are 38-45 x 14-16 x 11-12μm, subhyaline throughout development, finally becoming very dilute yellowish tan with darker septa in contrast.

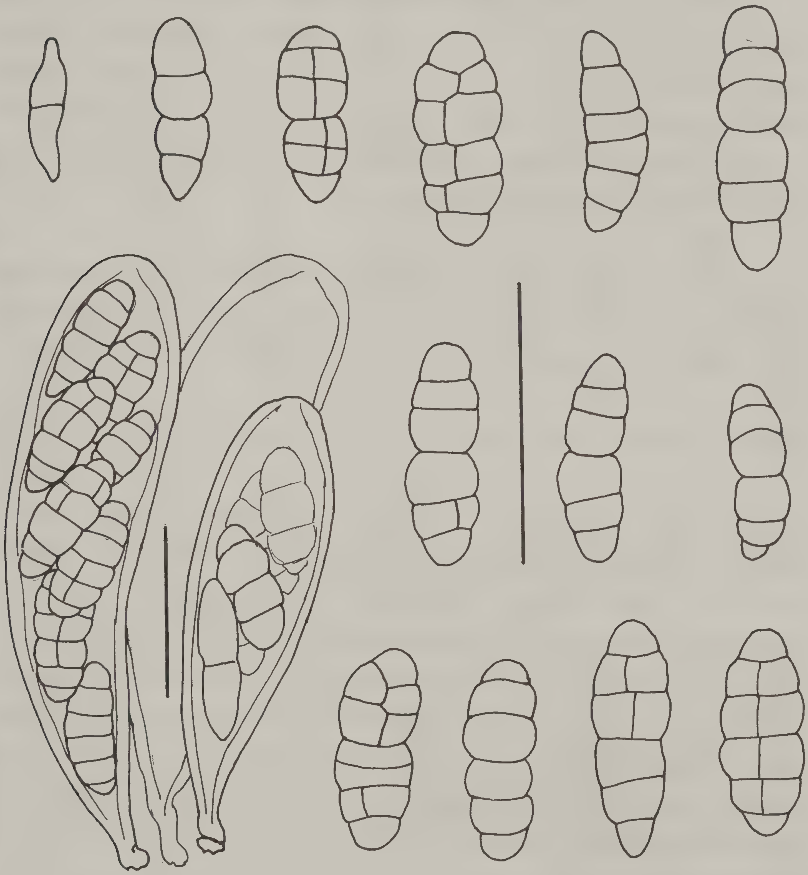

Fig. 3. *Macrospora scirpivora* asci and ascospores. Culture substrate: *Scirpus* stem on PCA. EGS 50-021. Bars = 50μm.

Ascospores of *M. scirpivora*, like those of *M. scirpinfestans*, may be forcibly ejected as far as the petri dish cover (7 mm), where they germinate readily. Other ascospores cluster at the ascoma opening without being ejected; these may enlarge, produce 1-2 additional transepta, and germinate in place. However, the increased size (to ca. 64μm in length) and extra septation are factors of overmaturity and germination, not characteristics of mature ascospores before release from the ascus.

Macrospora scirpivora is known at present as laboratory-produced teleomorphs from single *Nimbya scirpivora* conidia isolated from stem lesions of *Scirpus* specimens collected by D. A. Johnson: EGS 50-008 (Pullman, Washington, August 2001), EGS 50-020 and 50-021 (Wyoming, September 2001). Isolate EGS 50-021 produces ascomata more readily and in greater abundance than the other isolates under stated conditions of culture. Also, its ascoma production is slightly more rapid and more abundant than that of *M. scirpinfestans* under the same conditions.

Characteristics of source conidia, developed on field lesions held overnight in a damp chamber, are presented below along with a description of the anamorph colony, which produces enormous numbers of conidia on both PCA and the *Scirpus* substrate.

Nimbya scirpivora E. G. Simmons & D. A. Johnson, sp. nov. Fig. 4

Ex culturis in agaro PCA descripta. Colonia grisea, granulosa, ex fasciculis arborescentibus vel compactis conidiophororum et conidiorum constans. Conidiophora simplicia, ca. 15-40 x 4-5μm, locis conidiogenis 1-4; vel brevia, plurima, pulvinos compactos ad ca. 500μm diam. formantia. Conidia vulgo solitaria sed plerumque catenata, (5-)20-60(-120) x 5-8(-12)μm, subhyalina, (0-)3-8(-13) transverse distoseptata, interdum 1-2 transeptis genuinis insertis; conidia insigniter secondarie conidiophorogena. Habitatio typi in caule Scirpus acutus Muhl., Douglas, Wyoming, D. A. Johnson lect. Typus: partes ex cultura EGS 50-021 ex conidio ex caule Scirpus acutus in cellula humida EGS sejuncto, desiccatae et in ***BPI*** *841968 (Holotypus) et saltem* ***IMI*** *(isotypus) conservandae.*

New conidia arise in abundance on stem lesions of fresh host material held for 1-2 days in a damp chamber. They are readily isolated and germinate promptly. Fresh conidia are narrow-ovoid and commonly have a narrow, but never filiform, beak extension. Conidium bodies with at least four transepta

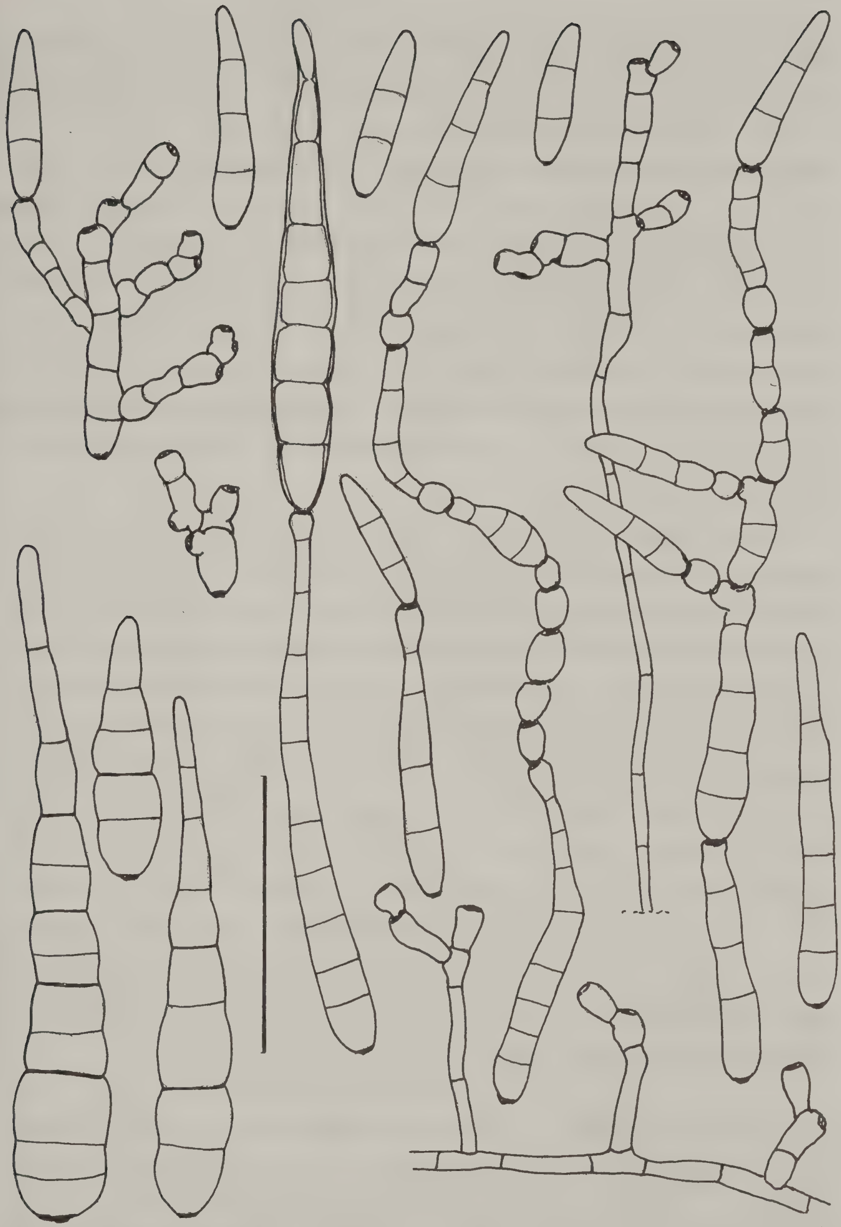

Fig. 4. *Nimbya scirpivora* conidia and conidiophores, including multiple conidiophore production by conidia (upper left); culture substrate *Scirpus* stem on PCA. Lower left: conidia produced on host lesions in damp chamber; original source of isolates. EGS 50-021. Bar = 50μm.

are 50-100 x 12-18μm plus a septate beak 20-50 x 2-4μm and show 4-9 transverse distosepta, through 1-2 to all of which eusepta are inserted; at this stage one longitudinal septum occurs rarely in one transverse segment. The conidium outer wall is moderately to strongly constricted at each true septum. Color is dilute straw color with most septa slightly darker and 1-2 much darker.

Colonies of *N. scirpivora* develop readily on PCA, appearing (without magnification) as a layer of small, dark grey, granular masses. Examination at 50X reveals that the layer consists primarily of openly arborescent or closely branched, compact clusters of conidiophores and enormous numbers of protruding, long-narrow conidia. Delicate vegetative hyphae spread within and on the surface of the agar and, to a minor extent, as sparse and very fine arachnoid aerial elements. There is no appreciable mass of non-sporulating vegetative mycelium.

Large numbers of conidiophores occur as simple, short, lateral branches of surface and aerial hyphae. These are ca. 15-40 x 4-5μm, with a conidiogenous locus at the ends of 1-4+ geniculate extensions; the terminal conidiogenous cell commonly becomes subobovate as it enlarges toward its apex. Other conidiophores, which generate the granular-cluster appearance of the colony, also arise from surface and aerial hyphae. These may branch repeatedly in an open manner and support an open spiny cluster of conidia; or they may branch so closely that they produce a compact cushion or sphere of short conidiophores and conidia up to ca. 500μm diam. Conidia may remain solitary, or chain formation may be rapid and profuse. Individual conidia in a chain usually produce only a single apical sporogenous site, but others may generate apical, multigeniculate conidiophores that are sporogenous at several loci. During rapid chain development, 1-2-celled intercalary conidia are abundant; these produce an apical conidiophore 1-5 cells long, or they may generate a secondary spore without producing a morphologically definable conidiophore other than an apical pore.

Conidium shape in culture is basically narrow-ovoid, sometimes narrow-ellipsoid. Otherwise the mature morphology and dimensions of conidia on any given kind of conidiophore are essentially impossible to predict. The patterns of variation include *conidia solitary*: any individual may remain small or reach maximum size for the taxon; *conidia in short chains*: all conidia are small, or small conidia arise from large, or large arise from small, or large arise from large; *conidia in long branching chains*: all conidia commonly are in the small range and decrease in size and degree of septation as the chain lengthens, but occasionally a relatively large unit is terminal or intercalary. Conidium size ranges from ca. 5 x 5-8μm for 1-cell units to a high range of 90-120 x 7-12μm.

Although conidia of the high size range are abundant at all stages of colony development, the major bulk of spores have moderate sizes near 20-60 x 5-8μm. Internal division of all conidia is distoseptate, with 0-13 internal cell locules; longitudinal septa have not been seen. Eu-transepta occur primarily in conidia in the maximum size range (1-2 among the 9-12 distosepta) and prominently throughout conidia of any size that have produced lateral conidiophores. All conidia are subhyaline except for the conspicuous basal hilum area and conidiogenous loci that terminate conidiophores; a very few conidia eventually become dilute tan as they age.

A striking feature in colonies of any age (2-3 d to 2-3 wks) is the abundance of intercalary conidia that produce conidiophores laterally from their body cells. Two examples are illustrated (Fig. 4, upper left): one conidium of only two cells shows four conidiogenous loci; another conidium of five cells bears a complement of four apical and lateral conidiophores and a total of eight conidiogenous loci. This pattern of conidiophore multiplication is not an aberration of age or other factor. Instead it is a prominent constituent of the sporulation apparatus, whose elaboration into hundreds of tightly interlocked conidiophores and conidia produces the pulvinate and spherical balls characteristic of the *N. scirpivora* colony in culture.

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CULTURAL STUDIES OF GYMNOPILUS SPECIES (CORTINARIACEAE, AGARICALES)

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ABSTRACT

In the search for taxonomic characters, cultural characteristics of six strains belonging to five species of *Gymnopilus* were studied. Strains of *Neolentinus suffrutescens* (brown-rot) and *Trametes versicolor* (white-rot) were included for comparison. The presence of phenol oxidases and the ability to grow in cellulose and lignin media were also assayed. We found that some micromorphological characteristics of the strains, such as size and form of arthrospores and other specialized elements have the potential to be useful as taxonomic characters. *Gymnopilus* has been recorded as a brown-rot or white-rot genus according to the particular species studied; all the species studied here are mainly cellulose decomposers, but also have the ability to decay lignin to a certain extent.

Keywords: brown-rot, white-rot, *Neolentinus, Trametes*

INTRODUCTION

Cultural features of fungi have been used to identify strains of economical importance, e.g. lignocellulolitic and ectomycorrhizal fungi (e.g. Nobles, 1965; Pantidou, 1961). Cultural studies can also be used as a source of characters for taxonomic studies (e.g. Mueller, 1984). The metabolites produced by fungi, such as pigments, alkaloids, enzymes, also may be used for these purposes. Among the enzymes, the phenol oxidases related with the type of rot (white-rot or brown-rot) have been widely used.

Few works have described cultural characters or the type of rot caused by *Gymnopilus*. Murrill (1940) mentioned that the type specimen of *G. armillatus* Murrill was found causing a whitish decay in a living red gum tree (*Liquidambar styraciflua* L.). Gilbertson (1974) described cultural features of *Gymnopilus sapineus* (Fr.) Maire and recorded it as a brown-rot fungus. Jacobsson (1989) studied a culture of *G. junonius* (Fr.) Orton, isolated from *Betula* sp. in Sweden, and Sede & López (1999) described a strain of *G. spectabilis* var. *pampeanus* (Speg.) Singer [as *G.*

pampeanus (Speg.) Singer], obtained from a standing *Eucalyptus* in Argentine. Hintikka (1982) studied the effect of carbon dioxide concentration on the germination of the basidiospores of 13 lignicolous basidiomycetes, including *G. penetrans* (Fr. : Fr.) Murrill. Tanesaka et al. (1993) measured the wood degrading ability of 68 basidiomycetes in culture, among them the white-rot *G. aeruginosus* (Peck) Singer.

In this paper we present data on cultural characteristics of five species of *Gymnopilus*. For each strain we described macro- and micromorphological features, the presence of extracellular phenol oxidases and the ability to grow in media prepared with lignin or cellulose.

MATERIAL AND METHODS

Six *Gymnopilus* strains were used, three of Mexican origin (42 = *G. subpurpuratus* Guzm.-Dáv. & Guzmán, 7432 = *G. subearlei*, 7438 = *G.* cf. *subearlei* Hesler), one from France [8219 = *G. penetrans* (Fr. : Fr.) Murrill] and two from Argentine [INTECH 444/01 and 47/99 = *G. spectabilis* var. *pampeanus* (Speg.) Singer]. *Neolentinus suffrutescens* (Fr. : Fr.) Fr. (brown-rot) and *Trametes versicolor* (L. : Fr.) Pilát (white-rot) were used as controls. Fruit bodies from which the *Gymnopilus* strains were isolated are deposited in the mycological herbarium IBUG except the Argentine strains, deposited at BAFC (Holmgren et al., 1981).

For the morphological characterization, the strains were grown on malt extract agar (MEA) and incubated at 25 °C in complete darkness. The parameters observed were, with some modifications, those considered by Nobles (1965). Growth rate was evaluated as the percentage of the Petri dish covered 10 days after inoculating the plate in the center. Also the macromorphological characterizations were made at the same time. Micromorphological observations were made 10 to 14 days after inoculation using a Zeiss K-7 compound microscope, from material mounted in 3% KOH and Congo red. For the solid media with cellulose (α cellulose, Sigma) and lignin (Curan 100 DD, Lignotech, Sweden, from *Quercus*), Paterson & Bride (1994) were followed. In these cases the measure was the biomass production. Extracellular phenol oxidases production was assayed according to Davison et al. in 1938 (Trigiano & Fergus, 1979).

RESULTS

Growth on lignin and cellulose media

All the cultures grew on cellulose and lignin media, except *Trametes versicolor*, which did not grow on lignin medium. The growth on lignin was very slow, being faster for *Neolentinus suffrutescens.* Among *Gymnopilus* strains, number 42 yielded the highest biomass production on both media (fig. 1).

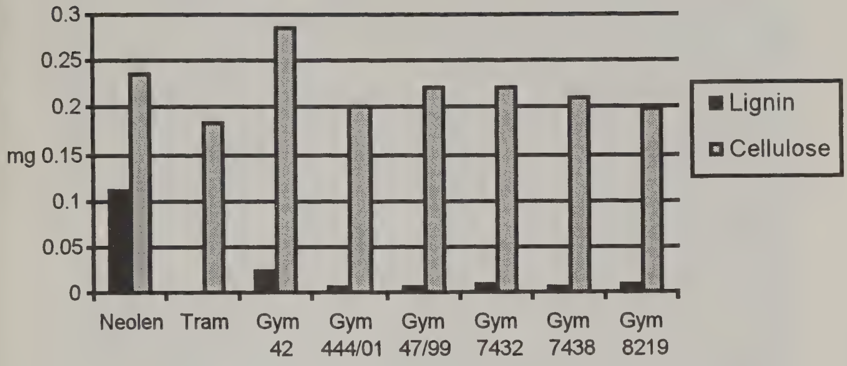
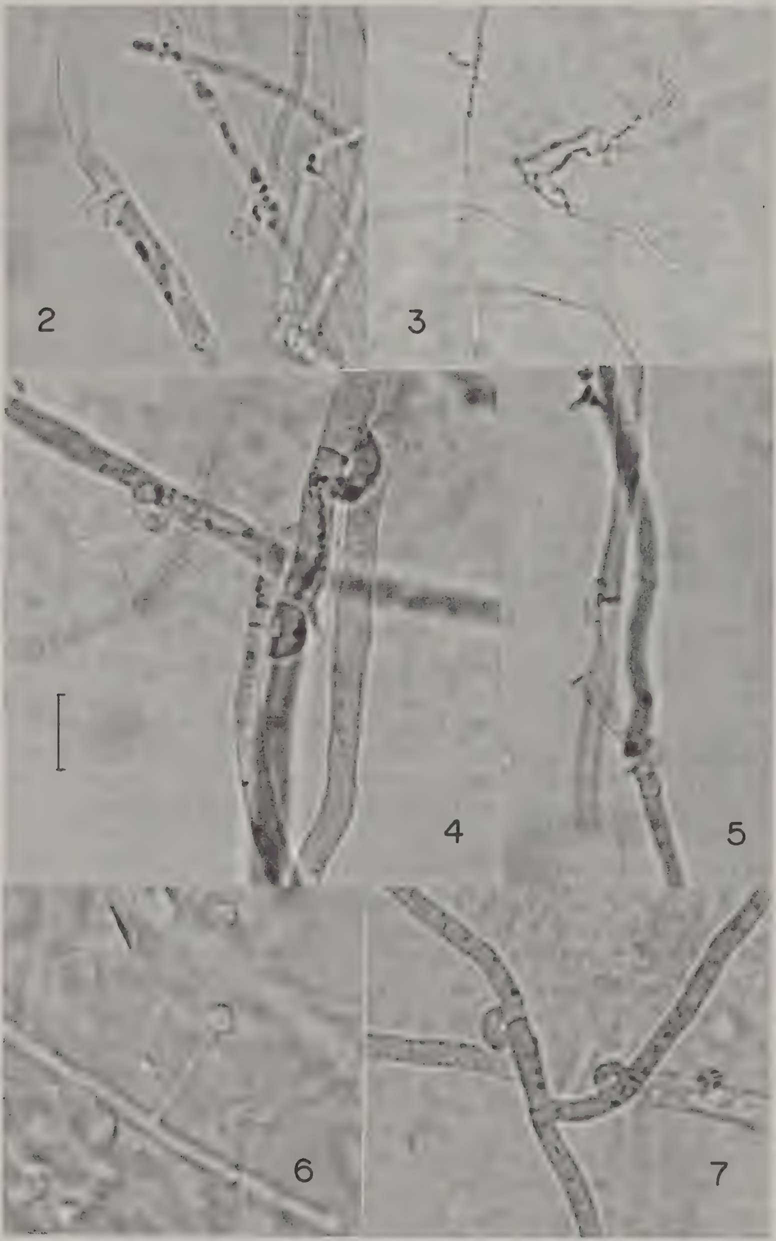


Fig. 1. Biomass production of the studied strains on lignin and cellulose media. Neolen: *Neolentinus suffrutescens,* Tram: *Trametes versicolor,* Gym 42: *Gymnopilus subpurpuratus,* Gym 444/01: *G. spectabilis* var. *pampeanus,* strain 444/01, Gym 47/99: *G. spectabilis* var. *pampeanus,* strain 47/99, Gym 7432: *G. subearlei,* Gym 7438: *G.* cf. *subearlei,* Gym 8219: *G. penetrans.*

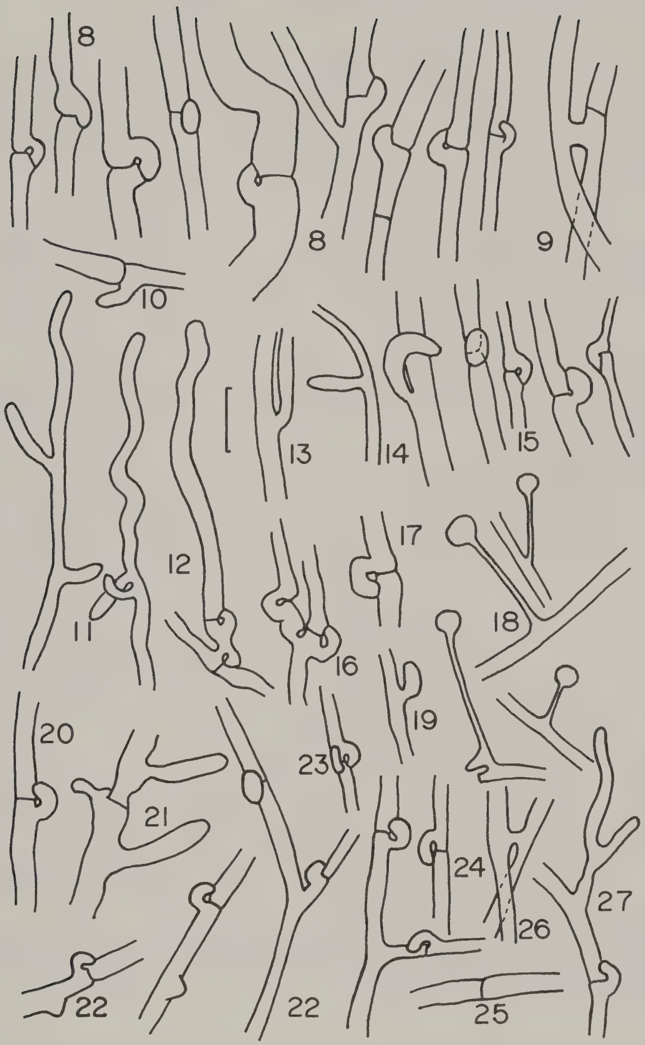
Strain descriptions

Gymnopilus penetrans (Fr. : Fr.) Murrill
Figs. 2 – 3, 8 – 12

Macromorphological characters: 70% of plate cover by the 10th day (5.95 cm); mat cottony, homogeneous, white; advancing zone superficial; margin uneven; reverse unchanged.
Oxidase reactions: gallic acid +, gum guaiac -, tannic acid -.
Micromorphological characters. Aerial mycelium: hyphae 1.2 – 4.8 µm diam., thin-walled, branched, septate, with clamp connections, some septae simple without clamps, with short branches similar to incomplete clamps, with transversal anastomoses, hyaline, many with granulose refringent content; arthrospores and chlamydospores absent. Advancing zone: hyphae flexuose abundant, with short branches and multiple clamps; arthrospores and chlamydospores absent.
Species code: 1.2.3.7.32.36.38.54.55
Material studied: strain 8219, vegetative isolation from fruitbody on wood (France, Dept. Pas-de-Calais, Merlimont, Réserve Biologique Domaniale, November 19, 1999, *L. Guzmán-Dávalos 8219,* IBUG).



Figs. 2 – 7. 2 – 3: *Gymnopilus penetrans*, 2: hyphae with clamp connections from aerial mycelium, 100X; 3: flexuose hyphae from advancing mycelium, 40X. 4 – 7: *G. spectabilis* var. *pampeanus*, INTECH 444/01, aerial mycelium, 100X, 4: hooked clamp connections, 5: irregular clamp, 6: capitate apex from narrow tapering hypha, 7: branched hypha with clamps.



Figs. 8 – 27. 8 – 12: *Gymnopilus penetrans.* 8 – 10: aerial mycelium, 8: hyphae septate with clamp connections, 9: anastomose, 10: hypha with short branch similar to a clamp. 11 – 12: advancing mycelium, 11: flexuose hyphae with short branches, 12: branched hypha with multiple clamps. 13 – 27: *G. spectabilis* var. *pampeanus.* 13 – 21: INTECH 444/01. 13 – 18: aerial mycelium, 13: branched hypha, 14: hyphae with short branch, straight or bent similar to a clamp, 15: hyphae with clamps, 16: hypha with multiple clamps, 17: hooked-inflated clamp, 18: capitate apices from narrow tapering hyphae. 19 – 21: advancing mycelium, 19: hypha with short branch similar to a clamp but without septa, 20: hypha with a hooked clamp, 21: branched hypha. 22 – 27: INTECH 47/99, aerial mycelium, 22: septate hyphae with clamps and two with protuberances, 23: multiple clamps, 24: hooked clamps, 25: septate hypha without clamp, 26: anastomose, 27: branched hypha with clamp. Scale bar = 8 µm.

Gymnopilus spectabilis* var. *pampeanus (Speg.) Singer
Figs. 4 –7, 13 – 33, 45 – 47

Macromorphological characters: 30% of plate cover by the 10th day (2.55 cm) (strain 444/01) and 40% of plate cover by the 10th day (3.4 cm) (strain 47/99); mat downy, homogeneous, white; advancing zone superficial; margin uneven; reverse unchanged.

Oxidase reactions: gallic acid +, gum guaiac +, tannic acid -.

Micromorphological characters strain 444/01. Aerial mycelium: hyphae 1.2 – 4 µm diam., thin-walled, branched, septate, with clamp connections, some inflated, hooked, multiple or irregular clamps, with short branches similar to incomplete clamps, hyaline, with or without granulose refringent content; arthrospores absent; chlamydospores absent; capitate apices (2.4 – 4.8 µm diam.) from narrow tapering hyphae (8 – 20 µm long), abundant. Advancing zone: hyphae with abundant short branches straight or bent similar to incomplete clamps; arthrospores, chlamydospores and capitate apices absent.

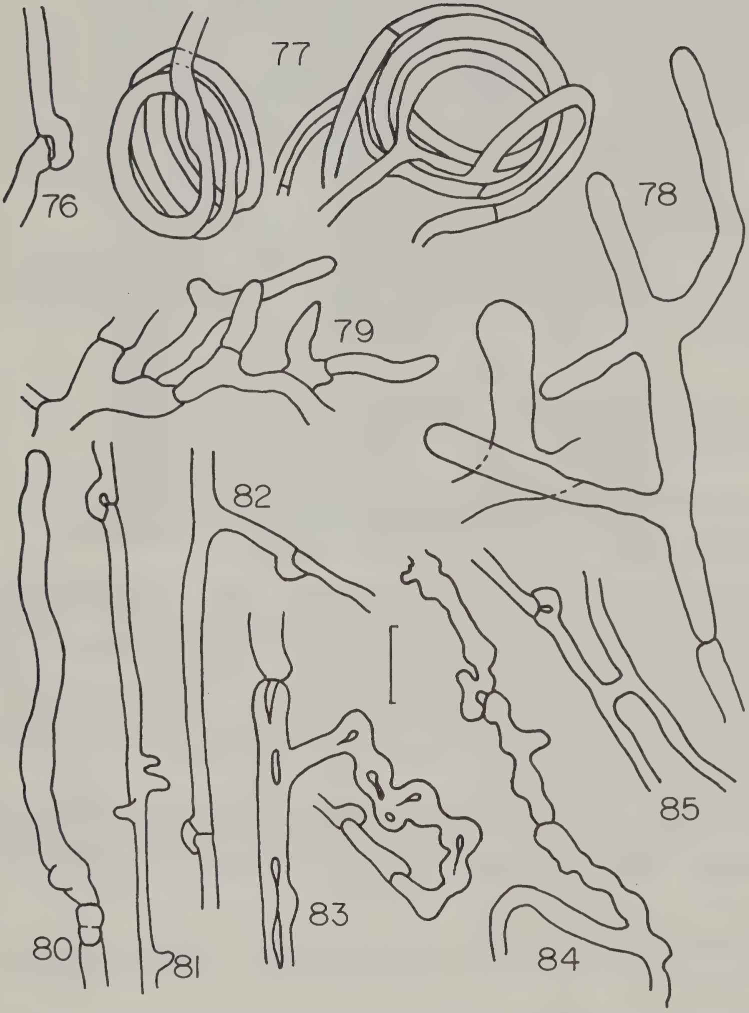
Micromorphological characters strain 47/99. Aerial mycelium: hyphae 0.8 – 3.2 µm, thin-walled, branched, septate, with clamp connections, some with multiple, septae rarely simple without clamps, few transversal anastomoses, with protuberances or very short branches, hyaline, with or without granulose refringent content; arthrospores 6.4 – 10.6 X 2 – 2.4 µm, cylindric, hyaline, with refringent content, uncommon; developing chlamydospores 7.2 – 10 X 6.4 – 8.8 µm, ellipsoid to globose, wall thin to subthick, hyaline, with or without granulose content, many terminal, few intercalar. Advancing zone: flexuose hyphae abundant, with many short branches; arthrospores and chlamydospores absent.

Species code strain 444/01: 1.2.3.7.36.38.54

Species code strain 47/99: 1.2.3.7.34.35.36.38.54

Material studied: strain INTECH 444/01, isolated by S. Sede from fruitbody on *Eucalyptus* sp. (Argentine, Buenos Aires, Capital Federal, El Rosedal, May 10, 1994, *S. Sede s.n.*, BAFC-2200). Strain INTECH 47/99, isolated by F. Pieckenstain from fruitbody below *Eucalyptus* sp. (Argentine, Buenos Aires, Chascomús, INTECH Campus, March 25, 1999, *C. Pereyra s.n.*).

Note: The strain 444/01 was the same described by Sede & López (1999). We did not observe chlamydospores in this strain but they did. They found a positive result with tannic acid and a negative with guaiacol.



Figs. 28 – 44. 28 – 33: *G. spectabilis* var. *pampeanus,* INTECH 47/99. 28 – 31: aerial mycelium, 28: hypha with small branches or protuberances, 29: branched hypha with protuberance and irregular clamp, 30: arthrospores, 31: chlamydospores, terminal and intercalar. 32 – 33: advancing mycelium, 32: flexuose branched hyphae with clamps, 33: irregular clamp. 34 – 44: *G. subearlei,* strain 7432. 34 – 39: aerial mycelium, 34: anastomose with clamps, 35: hyphae with clamps, 36: branched hypha with clamps, 37: hooked-inflated clamp, 38: arthrospores, 39: terminal chlamydospores. 40 – 44: advancing mycelium, 40: capitate apex from narrow tapering hypha, 41: short branches directly formed from the clamps, 42: hypha clamped and with a protuberance, 43: hypha branched with a hooked-inflated clamp, 44: flexuose hyphae. Scale bar = 8 µm.

12.8 X 2 – 2.8 µm, cylindric, phaseoliform to allantoid, thin-walled, hyaline, with refringent content, very abundant; chlamydospores 9.6 –13.6 X 8 – 10 µm, ellipsoid to globose, thin to thick-walled, hyaline, with or without granulose refringent content, or with guttules, terminal, many produced from subtending thinner hyphae. Advancing zone: hyphae thinner than the ones from the aerial mycelium, thin-walled, flexuose, branched, septate, with clamp connections, many inflated, and many short branches directly formed from the clamp; arthrospores and chlamydospores absent; only one capitate apex (2.8 µm diam.) from a narrow tapering hyphae (12.8 µm long) was observed.

Species code: 1.2.3.7.34.35.36.38.54

Material studied: strain 7432, vegetative isolation from fruitbody on wood [Mexico, Jalisco, Municipio de San Sebastián del Oeste, road San Sebastián del Oeste – La Haciendita (San Isidro), Arroyo Hondo, August 16, 1998, *L. Guzmán-Dávalos 7432*, IBUG].

Gymnopilus* cf. *subearlei R. Valenz., Guzmán & J. Castillo
Figs. 52 – 62

Macromorphological characters: 40% of plate cover by the 10th day (3.4 cm); mat downy, homogeneous, white; advancing zone superficial; reverse unchanged.

Oxidase reactions: gallic acid +, gum guaiac +, tannic acid -.

Micromorphological characters. Aerial mycelium: hyphae 1.6 – 5.6 µm diam., thin-walled, some flexuose to submoniliform, few branched, septate, with clamp connections, many clamps irregular, hyaline, with or without granulose refringent content; arthrospores absent; chlamydospores absent. Advancing zone: many hyphae septate without clamp connections, alternate with one septae clamped and then many septae without clamps; many hyphae flexuose and submoniliform; elements as short branches or subcapitate apices on short and thin hyphae present.

Species code: 1.2.3.7.32.36.38.54

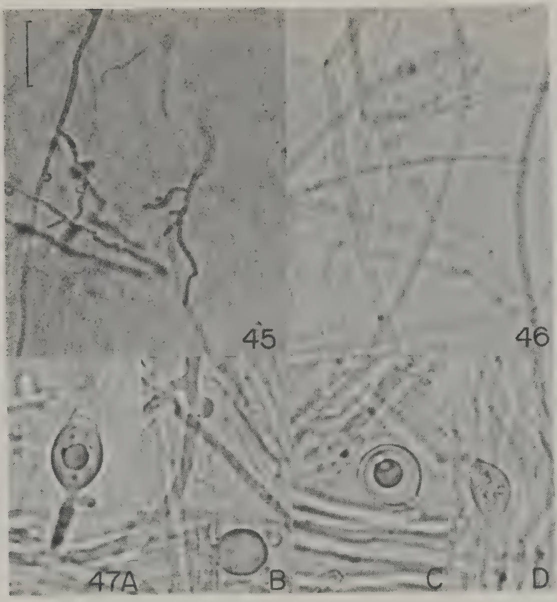
Material studied: strain 7438, vegetative isolation from fruitbody on wood [Mexico, Jalisco, Municipio de San Sebastián del Oeste, km 10 road San Sebastián del Oeste – La Haciendita (San Isidro), August 16, 1998, *L. Guzmán-Dávalos 7438*, IBUG].

Gymnopilus subpurpuratus Guzm.-Dáv. & Guzmán
Figs. 63 – 69

Macromorphological characters: 50% of plate cover by the 10th day (4.25 cm); mat downy, homogeneous, white; advancing zone superficial; reverse unchanged.

Oxidase reactions: gallic acid +, gum guaiac -, tannic acid -.

Micromorphological characters. Aerial mycelium: hyphae 1.6 – 4 (– 4.8) µm, thin-walled, branched, septate, with clamp connections, some clamps inflated, few transversal anastomoses, some hyphae submoniliform and others with small ramifications or protuberances, hyaline, with or without refringent granulose content; arthrospores 4 – 7.6 (– 11.6) X 1.6 – 2.8 µm diam., cylindric to subphaseoliform, thin-walled, hyaline or with abundant granulose refringent content, common; chlamydospores absent. Advancing zone: hyphae 2 – 4.8 µm diam., similar to those in

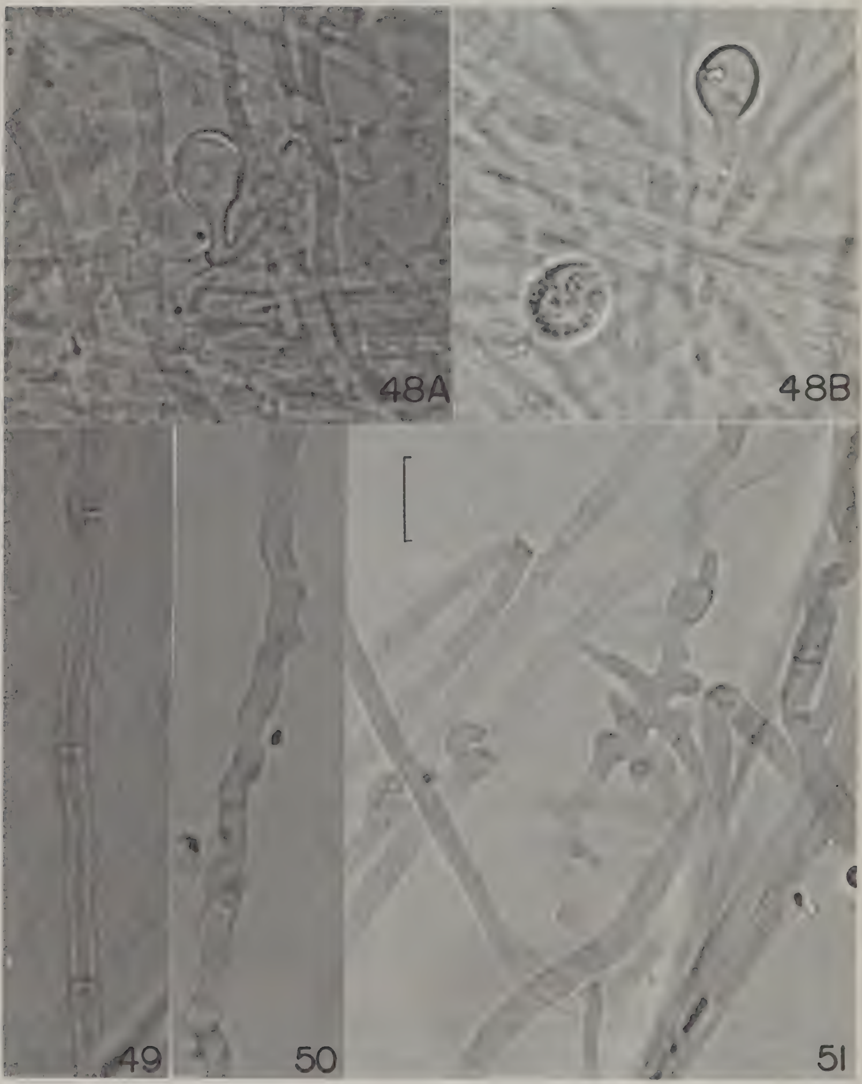


Figs. 45 – 47: *G. spectabilis* var. *pampeanus,* INTECH 47/99. 45: flexuose terminal hyphae from the advancing zone, 40X. 46 – 47: 100X, 46: hypha branched with clamp, 47: chlamydospores, A – C: terminal, D: intercalar.

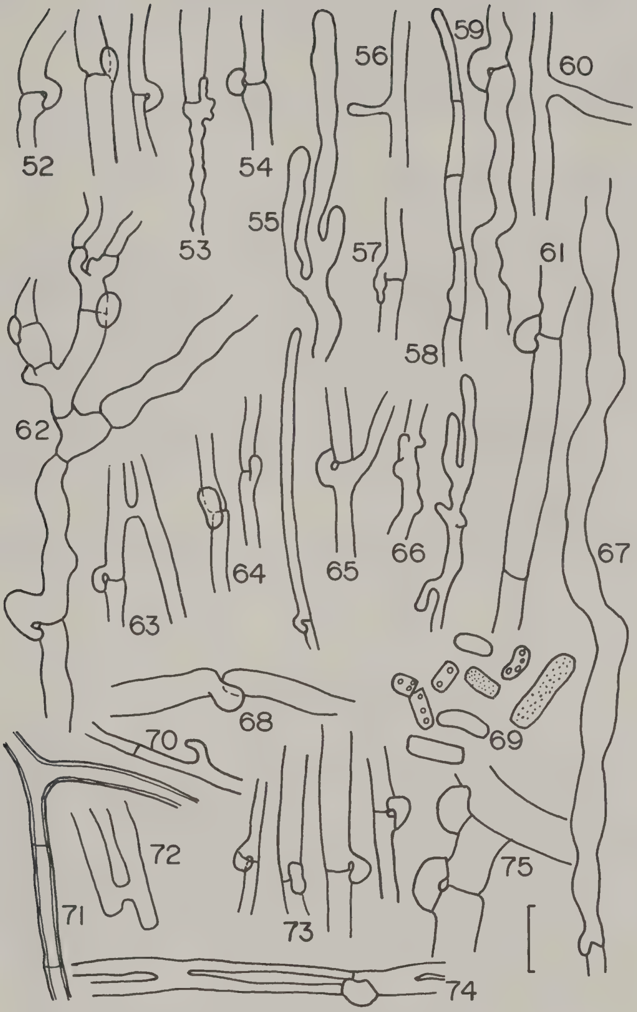
aerial mycelium, but submoniliform hyphae and anastomoses absent, with many flexuose hyphae; arthrospores and chlamydospores absent.
Species code: 1.2.3.7.35.36.38.55
Material studied: strain 42, isolated by A. Arias, vegetative from fruitbody on pine wood (Mexico, Jalisco, Municipio de Zapopan, Campus of Universidad de Guadalajara, Instituto de Botánica, July 19, 1990, *L. Guzmán-Dávalos 5154*, IBUG).

Neolentinus suffrutescens (Brot.) T. W. May & A. E. Wood
Figs. 70 – 79, 86 – 88

Macromorphological characters: 60% of plate cover by the 10th day (5.1 cm); mat downy, homogeneous, white; advancing zone superficial; reverse unchanged; fruit odor.
Oxidase reactions: gallic acid -, gum guaiac -, tannic acid -.
Micromorphological characters. Aerial mycelium: hyphae 1.2 – 4.8 μm diam., thin to very thick-walled, up to 2.5 μm thick, some hyphae almost compact, branched, septate, with or without clamps, transversal anastomoses common, some with short branches, hyaline, with or without homogeneous or granulose refringent content; arthrospores and chlamydospores absent; hyphal coils present. Advancing zone: hyphae 1.6 – 6.4 μm diam., swelling hyphae very abundant with rounded to



Figs. 48 – 51, 100X. 48 A - B: *G. subearlei*, strain 7432, terminal chlamydospores. 49 – 50: *G.* cf. *subearlei*, strain 7438, 49: hypha with a slightly irregular clamp and septae without clamps, 50: flexuose-submoniliform hypha. 51: *G. subpurpuratus*, flexuose branched hyphae in the advancing mycelium.



Figs. 52 – 75. 52 – 62: *G.* cf. *subearlei,* strain 7438. 52 – 56: aerial mycelium, 52: hyphae with clamps, 53: flexuose hypha with irregular clamp, 54: inflated clamp, 55: branched hypha, 56: hypha with a short branch. 57 – 62: advancing mycelium, 57: irregular clamp, 58: septate hypha without clamps, 59: flexuose hypha with clamp, 60: branched hypha, 61: septate hypha with and without clamps, 62: moniliform hypha. 63 – 69: *G. subpurpuratus,* aerial mycelium, 63: anastomose, 64: hyphae with clamps, 65: branched hypha with clamp, 66: hyphae with protuberances or small branches, 67: submoniliform hypha, 68: inflated clamp, 69: arthrospores. 70 – 75: *Neolentinus suffrutescens.* 70 – 74: aerial mycelium, 70: short branch, 71: septate without clamps thick-walled branched hypha, 72: anastomose, 73: hyphae with clamps, 74: septate with clamp thick-walled hypha. 75: hypha with inflated clamps from advancing mycelium. Scale bar = 8 um.

subcapitate apices, wall thin to subthick, branched, septate, with or without clamp connections, some clamps inflated, with transversal anastomoses, hyaline, many with homogeneous content; hyphal coils present.
Species code: 1.4.8.9.26.32.36.38.50.55
Material studied: strain INIREB – 80, origin Wisconsin, U.S.A.

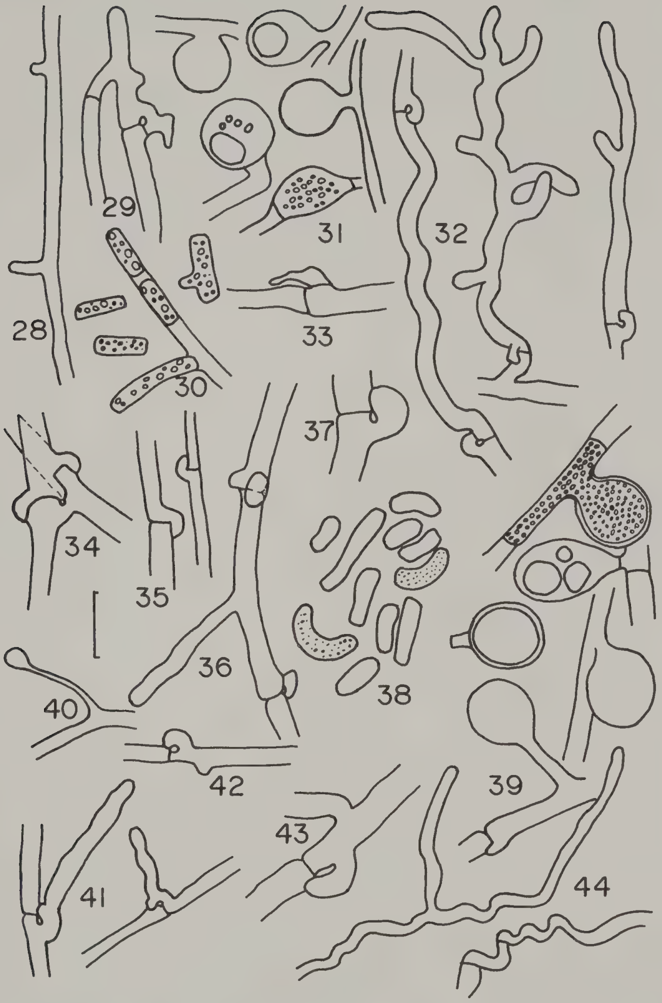
Trametes versicolor (L. : Fr.) Pilát
Figs. 80 – 85

Macromorphological characters: 50% of plate cover by the 10th day (4.25 cm); mat cottony, homogeneous, white; advancing zone superficial; reverse unchanged.
Oxidase reactions: gallic acid +, gum guaiac +, tannic acid +.
Micromorphological characters. Aerial mycelium: hyphae 1 – 3.2 µm diam., normal, flexuose, moniliform or with short and thin protuberances, thin to very thick-walled, branched, septate, with clamp connections, some septae without clamps, with transversal anastomoses, hyaline, with or without granulose refringent content; arthrospores and chlamydospores absent. Advancing zone: hyphae with many protuberances or thin and short branches.
Species code: 2.3.8.32.36.38.54.
Material studied: isolated by J. G. Marmolejo, vegetative from fruitbody on *Quercus* sp.

DISCUSSION

The macromorphology of all the cultures studied was very similar, giving no clue for their identification. The only dissimilar feature was the growth rate, with strains of *G. penetrans* and *G. subearlei* (7432) being the fastest and *G. spectabilis* var. *pampeanus* 444/01 the slowest. There were differences among the micromorphological characters; however, the differences were observed even between the two strains of *G. spectabilis* var. *pampeanus.* Although the presence of arthrospores was no constant between the cultures of the same species, it is probable that when present their form and size can be used as taxonomic characters among species.

The capitate apices originating from narrow tapering hyphae were also observed by Sede and López (1999). These authors mentioned that they reminded them of nematode-trapping structures, but as they did not present droplets, they could be something else. We found these structures very abundant in one strain of *G. spectabilis* var. *pampeanus* (444/01), but not in the other. Also they were present, but very scarce, in *G. subearlei* (7432). Sede and López (1999) anticipated that they could be a generic character. Our preliminary results show that they are not important at the genus level, but maybe would have a meaning in a more restricted level.



Figs. 76 – 85. 76 – 79: *Neolentinus suffrutescens.* 76 - 77: aerial mycelium, 76: irregular clamp, 77: hyphal coils. 78 – 79: advancing mycelium, 78: wider hyphae with rounded to subcapitate apices, 79: branched hypha without clamps. 80 – 85: *Trametes versicolor,* aerial mycelium, 80: flexuose hypha with clamp, 81: clamped hypha with protuberances or short branches, 82: branched hypha with clamps, 83: thick-walled moniliform septate with or without clamps hypha, 84: thin-walled moniliform septate with or without clamps hypha, 85: anastomose. Scale = 8 µm.

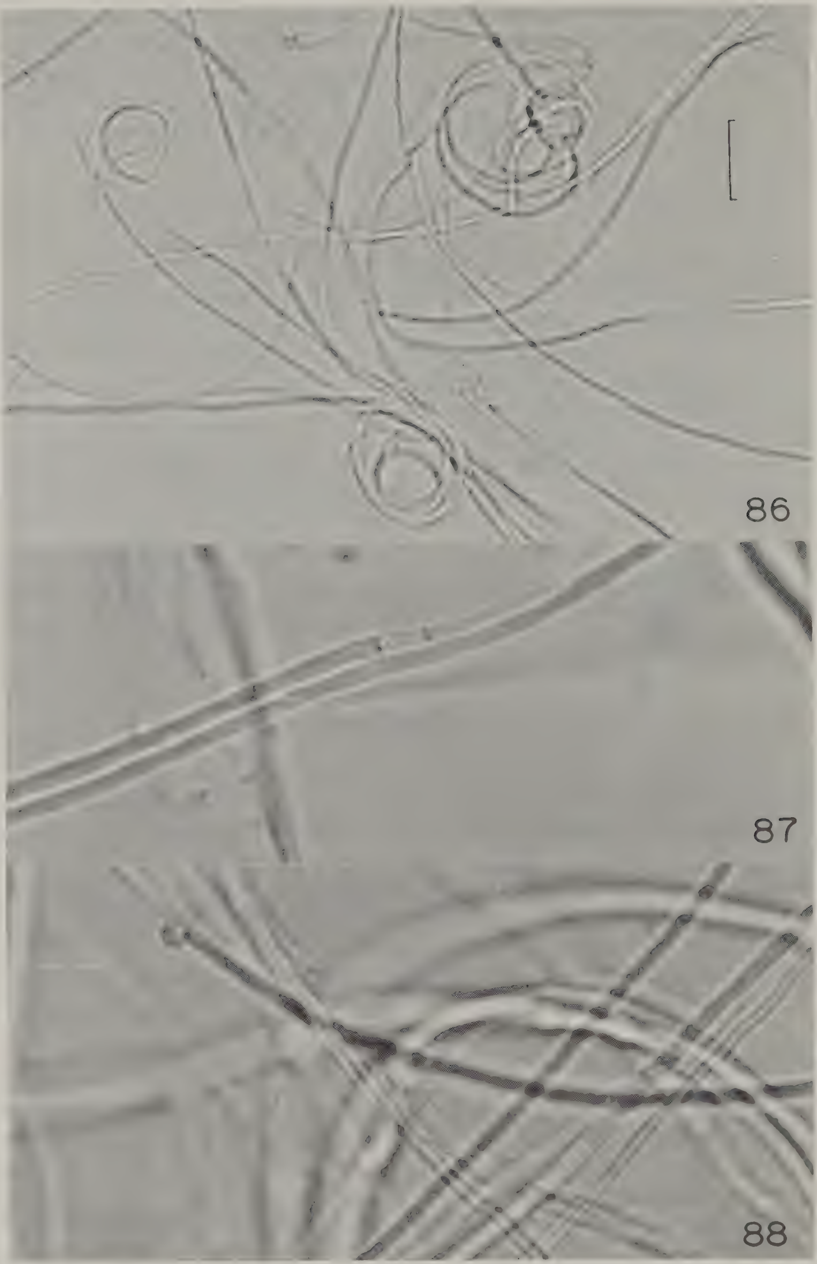


Fig. 86 – 88: *Neolentinus suffrutescens,* 86: hyphal coils, 40X, 24: thick-walled hyphae, 100X, 25: anastomose, 100X.

Gilbertson (1980) mentioned that brown-rot fungi generally are unable to decompose pure isolated cellulose, but here we find that all the fungi studied grew on the cellulose medium. It is surprising that the only white-rot fungi used in this study, *Trametes versicolor*, was not able to grow in the lignin medium; however, this mushroom gave positive in all the phenol oxidase tests. The contrary was true for *Neolentinus suffrutescens*, being able to grow in the lignin medium, but giving negative results with the oxidase tests. It seems that the availability of lignin and other factors in nature versus the quality and form of lignin in the laboratory media affected, in this experiment, the capability of the fungi to decay it. On the other hand, all the *Gymnopilus* strains could be grown on lignin media and gave positive results on at least one of the phenol oxidase reactions. These results indicated that *Gymnopilus* primary decomposes cellulose but also has the ability, to some degree, to decay lignin. For this reason the genus has been reported both as of white and brown-rot.

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ON THE REAL IDENTITY OF PLEUROTUS NEBRODENSIS IN SPAIN

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ABSTRACT. The identification of the vernal *Pleurotus* species with entirely white basidiomata growing on Umbelliferous root residues in Spain as *Pleurotus nebrodensis* is wrong. The presence of that taxon in Spain is for the moment excluded. The Spanish taxon is instead *Pleurotus eryngii* var. *elaeoselini*, reported here for the first time.

KEY WORDS: *Pleurotus eryngii* var. *elaeoselini*, Umbellifers.

INTRODUCTION

In the Mediterranean Basin the presence of a vernal *Pleurotus* species, growing on Umbelliferous root residues, producing entirely white basidiomata was stressed by many authors (Inzenga 1865, Bresadola 1881, Heim 1960, Cailleux et al. 1981, Venturella et al. 2000, 2002).

In the course of the years the rank of species, subspecies or variety was alternately attributed to these collections.

In the frame of a research project aimed at clarification of the very complex taxonomy of genus *Pleurotus*, Venturella et al. (2000) and Zervakis et al. (2001) separated, among the vernal *Pleurotus* species growing on root residues of Umbellifers, *Pleurotus nebrodensis* from *P. eryngii* var. *elaeoselini*, two taxa morphologically similar but ecologically and genetically well distinct.

On the basis of results arising from the Sicilian territory, field and herbarium investigations were enlarged to include other Mediterranean countries. In particular a field excursion in Spain was organized in late spring 2002 and a large number of basidiomata were collected in the province of Salamanca.

MATERIALS AND METHODS

On the basis of previous epistolary exchanges with mycological amateurs from the province of Salamanca (Spain) a field excursion in this area was performed in April 2002 in order to verify the real identity of *Pleurotus* species with entirely white basidiomata growing on Umbelliferous root residues.

The macroscopic and microscopic features of fresh basidiomata were observed using a Leica DMLS microscope.

The dried material was preserved in a paper box and subsequently rehydrated with KOH (5 %) for more detailed observations.

The herbarium specimens are kept in the Herbarium Mediterraneum of Palermo (PAL).

SPECIMENS EXAMINED

SPAIN: Paralejos de Abajo, provincia de Salamanca, approximately 4 km from Vitigudino, pasture, on calcareous soil, 780 m a.s.l., April 21st, 2002, on *Thapsia villosa* L., leg. G. Venturella; Lumbrales (Las Viñas), provincia de Salamanca, mixed pastures with *Ferula communis* L., *Magydaris panacifolia* (Vahl) Lange and *Elaeoselinum gummiferum* (Desf.) Samp., on calcareous soil, 600 m a.s.l., April 21st, 2002, on *Elaeoselinum gummiferum* (Desf.) Samp., leg. G. Venturella.

Typus – Lumbrales (Las Viñas), provincia de Salamanca, on calcareous soil, 600 m a.s.l., April 21st, 2002, on *Elaeoselinum gummiferum* (Desf.) Samp., leg. G. Venturella, (holotypus in PAL).

DISCUSSION

In past times a wide number of collections of white basidiomata, belonging to vernal *Pleurotus* species growing on root residues of Umbellifers, was identified by Spanish mycological amateurs as *Pleurotus nebrodensis* or *P. eryngii* var. *nebrodensis*.

The occurrence of these fructifications in mixed pastures characterized by the presence of different herbaceous plants belonging to the family *Apiaceae* such as *Ferula communis* L., *Thapsia villosa* L., *Magydaris panacifolia* (Vahl) Lange and *Elaeoselinum gummiferum* (Desf.) Samp. and sometimes the possibility to find the basidiomata exactly at the base of one or another of these plants caused a misapplication of the real name of the host-plant and the fungus too.

The microscopic features of basidiomata collected in Spain are clearly distinct from those of *P. nebrodensis* (Venturella et al. 2000). In particular basidiospores are irregularly ellispsoid to cylindrical and their size does not exceed 10-14 x 5-7 μm. Besides the presence of white basidiomata on *Elaeoselinum gummiferum* and *Thapsia villosa* root residues, the altitude of the localities where *Pleurotus* species were collected clearly exclude any relationship with *Pleurotus nebrodensis*.

Therefore white basidiomata collected on *Elaeoselinum gummiferum* and *Thapsia villosa* are here referred to *P. eryngii* var. *elaeoselini* and the presence of *P. nebrodensis* in Spain is for the moment excluded.

On the basis of previous studies (Zervakis & Venturella 1998, Zervakis et al. 2001) and in order to clarify the taxonomy of *Pleurotus* on Umbellifers species-complex in the Mediterranean area, further investigations will be carried out to evaluate the genetic affinities of the Spanish collections to the *P. eryngii* var. *elaeoselini* collections from Sicily and other Italian regions and Mediterranean countries.

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A TAXONOMIC SUMMARY OF CHYTRIOMYCES (CHYTRIDIOMYCOTA)

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ABSTRACT

The genus *Chytriomyces* was established by Karling to accommodate two similar species, *C. hyalinus* and *C. aureus*. The generic concept of *Chytriomyces* has become altered substantially from its original circumscription, mainly through attrition of utilizable generic characters, to its present simpler, yet less precise definition. Remaining reliable characters that help define Chytriomyces are: an epibiotic and operculate sporangium, and epibiotic resting spores. For each of the 34 species of Chytriomyces, a taxonomic description and ecological/distributional data are presented. The type of *Chytriomyces* is designated herein, and terminology pertinent to morphological features is discussed. A taxonomic key based on readily observable morphological character states, and figures derived primarily from the original literature, are presented to assist in species identification.

Key Words: chytrid, Chytridiomycetes, distribution, ecology, taxonomy.

INTRODUCTION

Karling (1945) established the genus *Chytriomyces* to accommodate two newly discovered aquatic chitinophilic species of zoosporic fungi. *Chytriomyces hyalinus* and *Chytriomyces aureus* were characterized by epibiotic operculate sporangia, extensive endobiotic rhizoids extending from a single rhizoidal axis that typically bore an apophysis or subsporangial swelling, posteriorly uniflagellate zoospores that swarmed in a vesicle outside the sporangium prior to release into the environment, and epibiotic resting spores that functioned as prosporangia in germination. Sexual reproduction and the sexual origin of the resting spore in *C. hyalinus* have been well documented (Koch 1959, Moore and Miller 1973, Miller 1977, Miller and Dylewski 1981).

The name *Chytriomyces* was proposed because of the characteristic *Chytridium*-like thallus exhibited by the newly described taxa. Karling (1945:363, 368) noted that except for the operculate sporangium, species of *Chytriomyces* were similar to species of *Rhizidium* (*sensu* Karling 1944), *Phlyctochytrium*, and *Rhizophydium*. *Chytriomyces hyalinus* and *C. aureus* were similar except for thallus color, and Karling did not designate one or the other as the type, nor has any other investigator.

As new species were discovered, the generic concept of *Chytriomyces* rapidly evolved. Karling may have anticipated such a process, for the original diagnosis, description, and discussion (Karling 1945) have subtle, implied, and occasionally contradictory addenda to the rather sparse original generic diagnosis, leaving open the potential for inclusion of wide morphological variation among the defining generic characters. Subsequent to Karling's establishment of the genus, discoveries were made of epibiotic, operculate fungi that lacked one or more of the fundamental morphological generic characters (Fay 1947, Karling 1947, 1949). Incorporation of informal alterations to the generic concept of *Chytriomyces* by Karling (1948:332, 1949:352) and Dogma (1976:136) as well as formal amendments (Sparrow 1960:538, Bostick 1968:98, Dogma 1983:385) included the absence of fundamental generic characters. The conceptual evolution of the genus may simply be a natural progression from a narrow and restricted generic concept based on two similar specific taxa, to a much broadened concept useful for inclusion of taxa exhibiting wide morphological variation. However, defining species of *Chytriomyces* through the exclusion of hallmark generic characters (features such as an apophysis or subsporangial swelling, an exogenous discharge vesicle, zoospores swarming in that vesicle prior to release into the environment, and an epibiotic resting spore) is inconsistent with the original generic concept. In the extreme, the genus has evolved to incorporate species in which the sporangium is simply epibiotic and operculate. Those two characters alone cannot justify species inclusion in the genus *Chytriomyces*, for they also delineate the genus *Chytridium* Braun (*cf.* Sparrow 1960).

The purpose of this taxonomic summary is to assemble taxonomic descriptions, illustrations, geographical distributions, substrates, hosts, and references for all species described to date. Assembly of this publication updates prior monographs and taxonomic summaries (Sparrow 1960, Longcore 1996). An identification key based on morphological characters is provided. Figures have been redrawn either from original literature with permission, as all living authors and extant publications have been asked (see Acknowledgments), or from living material.

THE TYPE OF *CHYTRIOMYCES*

As for most Chytridiomycota, in *Chytriomyces* no actual specimen remains from the original material that Karling examined and based his description. For the genus *Chytriomyces*, *C. aureus* and *C. hyalinus* were described sequentially in the same publication (Karling 1945), yet neither was designated as the type. Except for sporangial color, the two species are similar (Scogin and Miller 1971), and neither species is more like the generic description than the other. However, significantly more research (Koch 1959, Bostick 1968, Hasija and Miller 1971a, b, Scogin and Miller 1971, Moore and Miller 1973, Miller 1977, Miller and Dylewski 1981, Dorward and Powell 1982, 1983, Powell 1983, 1994) has been devoted to *C. hyalinus*, the form that appears more prevalent in nature, than to *C. aureus* (Willoughby 1959, Hasija and Miller 1971, Scogin and Miller 1971, Dorward and Powell 1982, 1983). In a practical sense, *C. hyalinus* is the species that is most frequently encountered when culturing from substrata, and therefore is most readily identified with the original generic description. Consequently, we herein designate *Chytriomyces hyalinus* Karling (1945), Am. J. Bot. 32:362-369, figs. 46-61 as the lectotype of the genus (ICBN Article 9.2, ICBN 2000).

Dogma (1976) synonymized *Amphicypellus* (Ingold 1944) with *Chytriomyces*, indicating that *Chytriomyces* (the later of the two genera to be described) is a "nomen conservandum", but no conservation of the name in the International Code of Botanical Nomenclature (2000) has been achieved. Thus, in our summary we are following the precedent set by Dogma, with the observation for this genus to be legitimate, conservation of the name *Chytriomyces* would have to be achieved.

TERMINOLOGY

For clarity it is essential to define several morphological terms. The **thallus** is considered to be the entire fungus, which may be differentiated at maturity into fertile and somatic portions. Zoospores, sporangia, rhizoidal systems, and resting spores are all parts of the thallus, even though they may be physically distinct and exist in different temporal and spatial situations. The **rhizoidal system** is the extension of the chytrid thallus that functions as an anchoring and absorptive apparatus and is composed of rhizoids and, on occasion, a single (rarely more than one) **apophysis**, which is synonymous with the terms **subsporangium** and **subsporangial swelling** (Karling 1936). The three terms that refer to the apophysate condition have been used synonymously and indiscriminately for morphologically similar but developmentally distinct structures (*cf.* Karling 1936, 1945, Sparrow 1936, Johnson 1971). Karling (1936) used the terms to describe a swelling of the germ tube subsequent to exogenous migration of the nucleus from the zoospore cyst/case into the germ tube. This nuclear event and the concurrent apophysate morphological condition occurs in many species of *Chytridium*, and the apophysis usually forms within (and rarely externally upon) the substrate. Subsequent to the **exogenous** (undergoing development outside of the zoospore case) nuclear migration, the nucleus returns to the zoospore case by way of the germ tube. There **endogenous** development (undergoing development inside the zoospore case, which at this point is termed the incipient sporangium) leads to development of a multinucleate sporangium. The entire process is known as **endo-exogenous development** (Karling 1936). In this context, an apophysis is a structural condition and component of the rhizoidal system resulting from a nuclear event. The timing of this type of development is sequential in that the apophysis forms prior to enlargement of the incipient sporangium. Conversely, in many species of the Chytridiales, and in the absence of endo-exogenous development, the initial rhizoidal axis may nonetheless become swollen, inflated, or bulbous in varying degrees (Barr 1984). An apophysis or subsporangial swelling of that nature is simply a structural condition of the rhizoidal system, developed independent of any functional, migratory, nuclear event. The timing of this type of developmental pattern is such that the endogenous development of the incipient sporangium and the development of the apophysis occur simultaneously.

Endo-exogenous development has not been directly observed in any of the species of *Chytriomyces*. Karling (1947:338) elucidated the developmental course of the nucleus for all species of *Chytriomyces* studied to that date, and made no mention of the endo-exogenous development that he described (Karling 1936) for *Chytridium lagenaria* (*cf.* Blackwell *et al.* 2002) Additionally, Karling (1945:367) stated that the development of *C. aureus* and *C. hyalinus* was so similar to that of *Rhizidium braziliensis* and *R. laevis* (Karling 1944) that a detailed description was unnecessary. There is no mention of endo-exogenous development with either of those species of *Rhizidium*. It is clear that Karling used the term "apophysis" for a structural feature of the initial rhizoidal axis, both dependent on (as in *Chytridium lagenaria*) as well as independent of (as in *Chytriomyces hyalinus*) a nuclear migration event. We now know that the various structures termed "apophysis," "subsporangium," and "subsporangial swelling" are not necessarily homologous structures. As examples of the terminology, the sporangium and resting spore of *C. cosmaridis* Karling (Figs. 36-39) and *C. stellatus* Karling (Figs. 66-68) were described as apophysate. The initial rhizoidal axis below the sporangium of *C. nodulatus* Haskins (Figs. 16, 19) was considered a subsporangial swelling.

It is from the germ tube, whether swollen into an apophysis or not, that the rhizoidal system develops. **Rhizoids** are usually filamentous, and may be widely extended and finely branched. The sporangia of *C. mortierellae* (Figs. 137, 138) and *C. multioperculatus* (Fig. 141) illustrate this feature. Like a rhizoid, a haustorium is an absorbing organ, but strictly of a parasitic fungus, and is often sac-shaped, club-shaped, bluntly lobed or coralloid (Karling 1932:43). Haustoria bear little or no resemblance to the more delicate thread-like extensions that constitute rhizoids. The sporangia of *C. gilgaiensis* (Figs. 52, 53) are subtended by lobed haustoria, and *C. cosmaridis* (Figs. 36-38) by spherical haustoria.

The term **epibiotic** refers to a portion of the thallus living or making growth on the surface of the substrate, and here we synonymize it with the term **extramatrical**. All but one species of *Chytriomyces* have epibiotic sporangia. The term **interbiotic** refers to any portion of the thallus living among, near, or between substrata. *Chytriomyces elegans* (Figs. 22-26) has interbiotic sporangia. The term **endobiotic** refers to a portion of the thallus living or growing within the substrate. All members of *Chytriomyces* have endobiotic rhizoids or haustoria. In this work, endobiotic is synonymous with the term **intramatrical**.

In the taxonomic descriptions that follow, characteristics of the zoospore ultrastructure have not been included, as few species have been investigated at that level. For those species that have been investigated, the reference is cited within the description. However, the organization of the microbody-lipid globule complex has been elucidated (Powell 1978, 1983, Powell and Roychoudhury 1992) as it relates to taxonomic and phylogenetic implications, as have aspects of the flagellar apparatus (Barr 1980, 1988, 1990, 2001, Barr and Desaulniers 1988, Barr and Hadland-Hartmann 1978, Dorward and Powell 1982).

THE SPECIES OF *CHYTRIOMYCES*: TAXONOMIC DESCRIPTIONS, REFERENCES AND DISTRIBUTION

1. CHYTRIOMYCES ANGULARIS Longcore

Mycologia 84:443, figs. 1-29. 1992.
PLATE 6, figs. 175-179

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium longer than wide, ellipsoid, gibbose or angular, hyaline, diameter 12 µm, height 22 µm, sessile or having an extramatrical stalk; sporangial wall smooth, with rounded to angular projections. **Rhizoidal system**: Rhizoidal axis only slightly thicker than remainder of the rhizoids, rhizoids branch from main axis at some distance from the sporangium. **Zoospore, discharge**: Operculum present, not persistent, apical or subapical, saucer shaped, diameter 7-8 µm, discharge pore single; discharge vesicle absent, zoospore discharge as an initial burst, zoospores quiescent for 1-2 minutes after sporangial dehiscence and prior to motility, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 4-5 µm in diameter, single lipid globule hyaline, flagellum 30 µm long. **Zoospore, ultrastructure**: Longcore 1992. **Resting spore**: Epibiotic, ovoid, angular or gibbose, thick-walled, smooth, hyaline. **Ecology and Distribution**: From water, on pollen, Longcore (*loc. cit.*: Maine), from soil, Letcher and Powell (unpublished observation, Virginia, North Carolina, and Utah), US.

2. CHYTRIOMYCES ANNULATUS Dogma

Nova Hedwigia 18:349, figs. 1-18. 1969.

PLATE 6, figs. 163-168

Vegetative: Thallus epibiotic or interbiotic. **Reproductive**: Sporangium pyriform or obpyriform, hyaline, diameter 10-31 μm, height 14-38 μm, having an extramatrical stalk; sporangial wall ornamented with 3-8 proximal collar-like annulations. **Rhizoidal system**: Apophysis spherical (not necessarily as a subsporangial swelling), diameter 8-15 μm, or saccate, 4-7 μm × 10-15 μm; filamentous rhizoids limited, sparsely branched. **Zoospore, discharge**: Operculum present, persistent, apical, saucer shaped, diameter 7-10 μm, not rigid after discharge, discharge pore single; discharge vesicle absent, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 4.7-6.5 μm in diameter, single lipid globule hyaline, flagellum 29-30 μm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Spherical or subspherical, 8-15 μm, hyaline, on an extramatrical stalk, containing a single globule. **Ecology and Distribution**: From leaf litter and soil samples, saprophytic on pine pollen, sweet gum pollen, and snake skin, weakly parasitic on *Rhizophydium coronum* sporangia and *Rhizophlyctis rosea* rhizoids, Dogma (*loc. cit.*: Michigan, Wisconsin, North Carolina, Maine, Virginia, New Hampshire, Vermont), on pollen, Letcher and Powell (2001:1031; 2002:766, Virginia), US; on pollen, Booth and Barrett (1971:362, E. Arctic), Lee (2000:60, Manitoba), CANADA; from water, on chitin, Czeczuga and Godlewska (1998), POLAND.

Based on actual observations of this organism (Letcher and Powell 2001, 2002), the species is emended as follows: *Chytriomyces annulatus* Dogma emend. Resting spore spherical, diameter 8-15 μm, subspherical or ovoid, 5-8 μm × 7-12 μm, the wall smooth or rarely with a single proximal collar-like annulation; with an extramatrical stalk and an endobiotic, spherical apophysis; contents of the resting spore a single large central hyaline globule occasionally surrounded by several smaller globules.

3. CHYTRIOMYCES APPENDICULATUS Karling

Bull. Torrey Bot. Club 74:335, figs. 16-37, 43-48. 1947.

PLATE 3, figs. 70-74

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium highly variable in size and shape: ovoid, pyriform, transversely flattened or reniform, hyaline to brown, diameter 10-80-(250) μm, height 10-50 μm, sessile; sporangial wall appendiculate or smooth. **Rhizoidal system**: Subsporangial swelling rarely present; main rhizoidal axis up to 18μm in diameter; filamentous rhizoids well developed, branched, coarse. **Zoospore, discharge**: Operculum present, not persistent, apical, subapical or lateral, saucer shaped, diameter 6-14 μm, discharge pore single; discharge vesicle present; zoospore discharge as a mass, zoospores swarming in vesicle outside sporangium before dispersal, vesicle separating from sporangium, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 4-6 μm in diameter, single lipid globule hyaline, flagellum 28-32 μm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, diameter 10-25 μm, or appendiculate, thick-walled, smooth, brown, and coarsely granular with a central vacuole; upon germination functions as a prosporangium . **Ecology and Distribution**: In water and soil, on chitin, Karling (*loc. cit.*, Virginia, New Jersey, New York, Connecticut), in water, on chitin, Miller (1965:223, Virginia), from soil, Dogma (1969:355, Michigan), US; from soil and water, on chitin, Willoughby (1961:306), from soil, on chitin, Willoughby (1962:122), UK; from soil, on pollen and keratin, Booth (1971b:951, British Columbia), CANADA;

from soil, on chitin, Karling (1967:122), NEW ZEALAND; from water, on chitin and keratin, Kiran (1993), INDIA.

"One of the peculiarities of this very distinct species is the tendency for some sporangia to form large amounts of "slime" beneath the area of discharge. In some material no vesicle was formed" (Sparrow 1960:544).

4. CHYTRIOMYCES AUREUS Karling

Am. J. Bot. 32:363, figs. 28-45. 1945.

PLATE 1, figs. 6-11

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or ovoid, golden-red, diameter 8-40 µm, sessile, sporangial wall smooth. **Rhizoidal system**: Apophysis spherical or subspherical, diameter 3-6 µm, filamentous rhizoids well developed, branched or coarse. **Zoospore, discharge**: Operculum present, not persistent, apical, saucer shaped; discharge pore single; discharge vesicle present; zoospores swarming in vesicle outside sporangium before dispersal; vesicle continuous with sporangium, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 3-3.5 µm in diameter, single lipid globule golden-red, flagellum 22-25 µm long. **Zoospore, ultrastructure**: Dorward and Powell 1982, 1983. **Resting spore**: Epibiotic, spherical, 6-20 µm, or ovoid, 6-10 µm × 12-16 µm, thick-walled, smooth, golden brown, with numerous closely packed granules or globules. **Ecology and Distribution**: In water, in exuviae of mayflies and on chitin, Karling, (*loc. cit.*, Connecticut, New York, Virginia), on pollen, Miller (1965:223, Virginia), in soil, on chitin, Dogma (1969:357, Michigan), Hasija and Miller (1970:1034, Ohio), US; in water, on chitin, keratin, and cellulose, Willoughby (1959:67, 1961:306), UK; in soil, on chitin, Karling (1967:121), NEW ZEALAND; in soil, on cellulose, Hassan (1993:35), EGYPT; in water, on chitin, Karling (*loc. cit.*), BRAZIL.

5. CHYTRIOMYCES CLOSTERII Karling

Bull. Torrey Bot. Club 76:352, figs. 1-5. 1949.

PLATE 1, figs. 29-35

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or pyriform, hyaline, diameter 5-25 µm, sessile; sporangial wall smooth. **Rhizoidal system**: Rhizoids a single, sparsely branched axis, sometimes extending to 120 µm. **Zoospore, discharge**: Operculum present, not persistent, apical, saucer shaped, diameter 4-6 µm, discharge pore single, with a discharge papilla; discharge vesicle present, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 2-2.5 µm in diameter, single lipid globule hyaline, flagellum 9-12 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical or ovoid, 7-12 µm, hyaline, thick-walled, smooth, with a large central globule surrounded by several smaller ones. **Ecology and Distribution**: In water, parasitic on *Closterium rostratum* Karling (*loc. cit.*), US.

"Apparently confined to one host species. It does not attack other species of *Closterium* or members of other genera of green algae" (Sparrow 1960:541).

6. CHYTRIOMYCES CONFERVAE (Wille) Batko

Zarys Hydromikologii p. 210, fig. 319. 1975.

Chytridium confervae (Wille) Minden, Kryptogamenfl. Mark Brandenburg, 5:368. 1911 (1915).

Phlyctochytrium confervae (Wille) Lemmerman, Abhandl. Naturwiss. Vereins Bremen 17:194. 1901.

Rhizidium confervae Wille, Vidensk. Selsk. Skr. Christiana (Mat.-Nat. Kl.): 1, figs. 1–3. 1899.

PLATE 3, figs. 89-95

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium ovoid, hyaline, diameter 15-32 µm, height 18-40 µm, sessile, sporangial wall smooth, with 2 sharp, curved teeth at apex. **Rhizoidal system**: Subsporangial swelling broadly fusiform, 13.5-24 µm long × 4.3-5.6 µm broad, filamentous rhizoids well developed, sparsely branched. **Zoospore, discharge**: Operculum present, persistent, apical, saucer shaped, diameter 10-12 µm, discharge pore single; discharge vesicle present; zoospores swarming in vesicle outside sporangium before dispersal; vesicle continuous with sporangium; zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 5-6 µm in diameter, single lipid globule hyaline, flagellum 27 µm long. **Zoospore, ultrastructure**: Barr and Hartmann 1976. **Resting spore**: Epibiotic or endobiotic, spherical or ovoid, thick-walled, smooth, hyaline or light yellow. **Ecology and Distribution**: In water, parasitic on *Tribonema*, Wille (1899:1), SWEDEN; Scherffel (1925:32), HUNGARY; Sparrow (1939:124), US; Rieth (1951:259), GERMANY; Sparrow (1957:532), Canter (1962:532), UK; Barr (1975:168, Ontario), Bandoni and Barr (1976:222, British Columbia), Barr and Hadland-Hartmann (1978:890, Ontario), CANADA; Batko (*loc. cit.*), POLAND.

Batko (1975) transferred *Chytridium confervae* (Wille) Minden to the genus *Chytriomyces* because of observation of an epibiotic resting spore.

7. CHYTRIOMYCES COSMARIDIS Karling

Sydowia, Annales Mycologici Ser. II, 20:119, figs. 1-7. 1967.

Sphalm. Chytriomyces cosmarii, Index of Fungi 3:483.

PLATE 2, figs. 36-40

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or subspherical and slightly flattened at the base, diameter 12-42 µm, golden-orange, sessile, having an internal, basal peg; sporangial wall smooth, surrounded by a slightly orange to yellow halo 9-12 µm thick. **Rhizoidal system**: Apophysis spherical or subspherical, diameter 6-9 µm, filamentous rhizoids lacking. **Zoospore, discharge**: Operculum present, persistent, apical or lateral, saucer shaped, diameter 6-10 µm, with a broad opaque to hyaline zone of substance or matrix underneath, discharge pore single; discharge vesicle present, zoospores swarming in vesicle outside sporangium before dispersal; vesicle continuous with sporangium, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 2-2.6 µm in diameter, with a single brilliantly refractive yellow-orange lipid globule, flagellum 11 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Spherical or ovoid, 8-12 µm diameter, thick-walled, smooth, hyaline to light yellow and surrounded by a slightly yellowish halo 6-8 µm thick; contents coarsely granular with a single large central globule. **Ecology and Distribution**: From soil, a hillside sheep paddock, parasitic on *Cosmarium* sp., Karling (*loc. cit.*: Taita, Wellington Province), NEW ZEALAND; from water, Czeczuga (1994), POLAND.

The original spelling of the epithet was "*cosmarii*", which Karling believed to be a mistake and in error (*sphalmate*); Karling (1967) attempted to correct the error to "*cosmaridis*" by making an indelible hand correction on circulated reprints of the original description. Index of Fungi (3:483) retained the original spelling. Karling (1977) validated "*cosmaridis*" by using that epithet in his revisionary treatment of the Chytridiomycetes.

8. CHYTRIOMYCES ELEGANS (Ingold) Dogma
Philippine J. Biol. 5:136. 1976.
Amphicypellus elegans Ingold, Trans. Br. Mycol. Soc. 27:93-97. 1944.
PLATE 1, figs. 22-28

Vegetative: Thallus interbiotic. **Reproductive**: Sporangium spherical, hyaline, diameter 8-16 µm, sporangial wall smooth; sporangium surrounded by a mucilaginous secretion. **Rhizoidal system**: Apophysis spherical, diameter 3-5 µm, filamentous rhizoids well developed, branched. **Zoospore, discharge**: Operculum present, persistent, apical or subapical, saucer shaped; discharge pore single; discharge vesicle present, zoospores swarming in vesicle outside sporangium before dispersal; vesicle continuous with sporangium, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 3.5-4.5 µm in diameter, single lipid globule hyaline. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, thick-walled, yellow, ornamented with stiff, rod-like hairs. Young resting spore surrounded by a halo of colorless material detectable with gentian violet in aniline water; immediately beneath the resting spore a swelling resembling an apophysis, from which the rhizoidal system emerges; resting spore thallus surrounded by a mucilaginous secretion. **Ecology and Distribution**: Saprophytic on dead cells of *Ceratium hirundinella* and *Peridinium*, Ingold (*loc. cit.*), UK; Canter (1951:151), UK, DENMARK, SWEDEN, ITALY; parasitic on *Ceratium*, Paterson (1958:91), US; from soil, on green algae, Dogma (1976:136), PHILIPPINES.

Dogma (1976) moved the type species of *Amphicypellus, A. elegans* into *Chytriomyces*. Because *Amphicypellus* was described first, and hence would have nomenclatural precedence, *Chytriomyces* needs to be conserved formally.

9. CHYTRIOMYCES FRUCTICOSUS Karling
Bull. Torrey Bot. Club 76:353, figs.18-52. 1949.
PLATE 3, figs. 79-83

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium appendiculate, spherical, pyriform or irregular, hyaline or light brown, diameter 17-35 µm, sessile, sporangial wall appendiculate. **Rhizoidal system**: Apophysis subspherical, elongate, fusiform or angular, diameter 8-20 µm; filamentous rhizoids well developed, branched, with a bushy appearance, branches occasionally extending for a distance of 275 µm. **Zoospore, discharge**: Operculum present, not persistent, apical, saucer shaped or dome shaped, diameter 4-8 µm, discharge pores one or two, discharge papillae present, one or two, discharge tubes present, one or two; discharge vesicle present, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 4-6 µm in diameter, single lipid globule hyaline. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, ovoid, or angular, 18-30 µm, verrucose or spiny, light amber or greenish-brown, contents finely granular. **Ecology and Distribution**: From water and soil, on chitin, Karling (*loc. cit.*), US.

"About 18 per cent of the sporangia and resting spores were formed from thalli which had developed from the germ tube of the zoospore and not by the expansion of the zoospore body itself. The type of development seemed dependent upon the behavior of the nucleus of the encysted zoospore. If it remained in the cyst a *Rhizidium*-like development ensued, whereas if it passed into the germ tube the less typical method of development was undergone. The sporangia are quite variable in shape and [the rhizoid] may have one to three apophyses.

As noted by Karling (1947) in other species of *Chytriomyces*, a single nucleus is present in the sporangial rudiment until the latter reaches full size" (Sparrow 1960:545).

10. CHYTRIOMYCES GILGAIENSIS Willoughby
Arch. Mikrobiol. 52:102, figs. 6 a-l. 1965.
PLATE 2, figs. 51-56

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium pyriform, hyaline, diameter 5-15 µm, height 8.5-20 µm, sessile, sporangial wall smooth. **Rhizoidal system**: Haustorium lobed. **Zoospore, discharge**: Operculum present, persistent, apical or lateral, saucer-shaped, diameter 5-8.5 µm; discharge pore single; discharge vesicle unknown, zoospore discharge unknown, zoospore motility unknown. **Zoospore, microscopic**: Zoospores with a single hyaline lipid globule. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, pyriform, 12 µm diameter, hyaline, thin-walled, tuberculate, containing 1-3 large hyaline globules. **Ecology and Distribution**: From soil from a gilgai depression, parasitic on *Nowakowskiella crassa* Karling, Willoughby (*loc. cit.*: Victoria), AUSTRALIA.

11. CHYTRIOMYCES HELIOZOICOLA Canter
Trans. Br. Mycol. Soc. 49:633, fig.1, a-s. 1966.
PLATE 2, figs. 57-61

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium sessile, ovoid or broadly ovoid, diameter 8.5-22 µm, hyaline, 10-24 µm high × 8.5-22 µm broad , sporangial wall smooth. **Rhizoidal system**: Filamentous rhizoids limited, lobose tufts arising from a single axis. **Zoospore, discharge**: Operculum present, not persistent, apical, rarely lateral, 5-13 µm diameter, saucer shaped, discharge pore single; presence or absence of discharge vesicle, and mode of zoospore discharge unknown. **Zoospore, microscopic**: Zoospores spherical, 2.5-3 µm in diameter, hyaline, containing a single anterior, spherical, highly refractive lipid globule and a single posterior, less refractive, ovoid body whose longer axis is set at right angles to the direction in which the zoospore moves, flagellum 19 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, 5-10 µm diameter, hyaline, thick-walled, smooth, containing 1-2 large refractive globules; asexually formed. **Ecology and Distribution**: From lake plankton, parasitic on the heliozoan *Raphidiocystis lemani* Penard, Canter (*loc. cit.*: Esthwaite Water and Windermere, English Lake District), UK.

12. CHYTRIOMYCES HYALINUS Karling (TYPE)

Am. J. Bot. 32:363, figs. 46-61. 1945.

Chytriomyces hyalinus emend. Bostick 1968. J. Elisha Mitchell Sci. Soc 84:94-99.

Synonymy: *Chytriomyces nodulatus* Haskins, Trans. Br. Mycol. Soc. 29:137, text figs. 1-8. 1946.

PLATE 1, figs. 1-5 (*C. hyalinus*); PLATE 1, figs. 16-21 (*C. nodulatus*)

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical, hyaline, diameter 10-60 µm, sessile, sporangial wall smooth. **Rhizoidal system**: Apophysis spherical, subspherical, elongate, or fusiform, diameter 3-7 µm; filamentous rhizoids well developed, branched, coarse, extending for a distance of 300 µm. **Zoospore, discharge**: Operculum present, not persistent, apical or subapical, saucer shaped, diameter 8-16 µm, discharge pore single; discharge vesicle present, zoospores swarming in vesicle outside sporangium before dispersal; vesicle continuous with sporangium, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 3-3.5 µm in diameter, single lipid globule hyaline, flagellum 18-20 m long. **Zoospore, ultrastructure**: Dorward and Powell 1982, 1983, Powell 1983, 1994. **Resting spore**: Epibiotic and endobiotic, spherical, 10-20 µm diameter, ovoid, pyriform, clavate, elongate, or angular, thick-walled, smooth, light brown; contents a large central refractive globule surrounded by a few to several smaller ones; sexually formed, functioning as a prosporangium in germination. **Ecology and Distribution**: In water, on chitin, Karling (*loc. cit.*, Connecticut, New York, Virginia), on chitin, keratin, and pollen, Miller (1965:223, Virginia), on pollen, Bostick (1968:94, North Carolina), Hasija and Miller (1970:1035, Ohio), from soil, on pollen, Booth (1971a:939, Oregon, California, Nevada), from soil, Moore and Miller (1973:147, Ohio), in water, Roane and Paterson (1974:149, Virginia), in water, on pollen, Sparrow and Lange (1977:1887, Michigan), from soil, on pollen, Letcher and Powell (2001:1031; 2002:766, Virginia), US; from soil, on chitin, Sparrow (1957:532), from soil and water, on chitin, Willoughby (1961:306), from soil, on chitin and keratin, Willoughby (1962:122), UK; from soil, on pollen, Booth (1969:143, 1971c:198, British Columbia), on chitin, Booth (1971b:954, British Columbia), CANADA; from water, on chitin, Karling (*loc. cit.*), BRAZIL; from soil, on chitin, keratin, and cellulose, Karling (1967:121), NEW ZEALAND; from soil, on keratin, Karling (1981:656), VENEZUELA; on chitin, Karling (1966:57), Das-Gupta (1982:213), INDIA; from soil on chitin, keratin, and cellulose, Karling (1987:142), TRINIDAD, PANAMA; on chitin, Karling (1968:176), Pitcairn Island, OCEANIA; from soil, on chitin, Willoughby (1965:103), AUSTRALIA, from water, on pollen, Chen and Chien (1995:238), TAIWAN.

"Common in bogs in Michigan; nodulate as well as smooth-walled sporangia were observed." (Sparrow 1960:541). As such, the species was synonymized with *Chytriomyces nodulatus* Haskins. "This species frequently occurs in company with *Polychytrium aggregatum* on purified shrimp chitin bait" (Sparrow 1960:541).

13. CHYTRIOMYCES HYALINUS v. GRANULATUS Karling

Sydowia, Annales Mycologici Ser. II, 20:120, figs. 8-15. 1967.

PLATE 1, figs. 12-15

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or subspherical, hyaline, diameter 12-120 µm, sessile, sporangial wall smooth. **Rhizoidal system**: Apophysis spherical, main axis 6-16 µm at base, filamentous rhizoids well developed, branched or coarse, extending for distances up to 400 μm. **Zoospore, discharge**: Operculum present, persistent, apical or subapical, saucer shaped, diameter 7-19 μm; discharge pore single; discharge vesicle present, zoospores swarming in vesicle outside sporangium before dispersal; vesicle continuous with sporangium, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical or slightly ovoid, 5-6 μm in diameter, hyaline, with several small refractive lipid globules, flagellum 22-26 μm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, 8-18 μm diameter, ovoid, 6-9 μm × 10-16 μm, or irregular; thick-walled, smooth, light brown, containing one or more large central refractive globules surrounded by several smaller ones. **Ecology and Distribution**: From soil, saprophytic on bleached corn leaves, chitin, and snake skin, Karling (*loc. cit.*), NEW ZEALAND; on cellulose, Karling (1968:176), Cook Islands, OCEANIA.

"This variety was widely distributed in New Zealand, and strikingly similar to *C. hyalinus*, except for its slightly larger non-guttulate zoospores. Also, its sporangia attained greater size [than *C. hyalinus*] and were usually non-apophysate. While *C. hyalinus* has a predilection for chitinic substrata this variety occurred more commonly on cellulosic substrata such as corn leaves and onion skin, although it grew to some extent on snake skin and shrimp chitin" (Karling *loc. cit.*).

14. CHYTRIOMYCES LAEVIS Karling

Nova Hedwigia 44:137, figs. 1-18. 1987.
PLATE 5, figs. 131-136

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or obpyriform, hyaline, diameter 10-30 μm, sessile, sporangial wall smooth. **Rhizoidal system**: Apophysis present as a haustorium, spherical, diameter 2.5-4 μm, with no additional filamentous rhizoids. **Zoospore, discharge**: Operculum present, persistent, apical, saucer shaped, diameter 8-26 μm, discharge pore single; discharge vesicle absent; zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 4-5 μm in diameter, single lipid globule hyaline. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, 8-20 μm diameter, hyaline, thick-walled, smooth, with a large central globule surrounded by smaller ones. **Ecology and Distribution**: From a soil-water culture collected at a stream bank, parasitic on *Pythium* sp. growing on snakeskin, Karling (*loc. cit.*), PANAMA.

15. CHYTRIOMYCES LUCIDUS Karling

Bull. Torrey Bot. Club 76:353, figs. 6-17. 1949.
PLATE 3, figs. 75-78

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium transversely flattened or reniform, hyaline, diameter 28-66 μm, height 18-44 μm, sessile, sporangial wall smooth. **Rhizoidal system**: Subsporangial swelling present, filamentous rhizoids well developed, coarse, often extending for a distance of 400 μm and becoming thick-walled with age. **Zoospore, discharge**: Operculum present, not persistent, apical, saucer shaped, diameter 4-8 μm, discharge pore single, discharge papilla one; discharge vesicle present, zoospores quiescent in vesicle outside sporangium before dispersal, vesicle separating from sporangium, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 5.8-6.2 μm in diameter, with a single hyaline lipid globule. **Zoospore, ultrastructure**: Unknown.

Resting spore: Epibiotic, ovoid, 15-18 µm × 20-25 µm, hyaline, containing numerous angular refractive bodies; thick-walled, smooth. **Ecology and Distribution**: From soil and water, on cellulose, Karling (*loc. cit.*, Maryland, Virginia), US.

16. CHYTRIOMYCES MACRO-OPERCULATUS Karling
Nova Hedwigia 34:652, figs. 24-38. 1981.
PLATE 4, figs. 120-124

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium appendiculate, ovoid, or broadly pyriform, hyaline, diameter 10-124 µm, height 16-160 µm, predominantly sessile, rarely stalked and subtended by a swelling, sporangial wall appendiculate, smooth. **Rhizoidal system**: Apophysate or nonapophysate; basal rhizoidal axis 4-8 µm diameter, usually arising at one or more places on the sporangium; filamentous rhizoids well developed, branched, coarse, extending for distances up to 80 µm. **Zoospore, discharge**: Operculum present, persistent, apical or lateral, saucer shaped, diameter 5-57 µm, discharge pore usually single, sometimes 2 or 3, up to 57 µm diameter; discharge vesicle present, zoospores swarming in vesicle outside sporangium before dispersal; vesicle continuous with sporangium; zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 4.5-5 µm in diameter, single lipid globule with grayish granular contents, flagellum 18-22 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, ovoid, angular, thick-walled, appendiculate, 7-40 µm diameter, reddish-brown. **Ecology and Distribution**: From soil, saprophytic on cellophane and bleached cotyledons of corn, Karling (*loc. cit.*), VENEZUELA.

17. CHYTRIOMYCES MACRO-OPERCULATUS v. HIRSUTUS Karling
Nova Hedwigia 34:655, figs. 39-45. 1981.
PLATE 4, fig. 125

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical, ovoid, or pyriform, diameter 54-60 µm, height 72-84 µm, sessile, sporangial wall appendiculate and ornamented, bearing numerous long, branched hairs which may extend for distances up to 600 µm in the surrounding water and often form a dense weft of filaments. **Rhizoidal system**: Non-apophysate, rhizoidal axes up to 12µm diameter, usually at the base of the sporangium, sometimes at the apex and sides, with irregular convolutions; filamentous rhizoids well developed, branched, extending for distances up to 400 µm. **Zoospore, discharge**: Operculum present, persistent, apical or lateral, dome shaped, diameter 12-18 µm, discharge pore usually single, sometimes 2 or 3; discharge vesicle present, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 4.5-5 µm in diameter, lipid globules many, hyaline. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, 4.5-5 µm diameter, bearing abundant coarse hairs, brown, with numerous granules which may fuse and form several refractive globules. **Ecology and Distribution**: From soil, saprophytic on cellophane, Karling (*loc. cit.*), VENEZUELA.

"Except for its hirsute sporangia and smaller opercula, the development and general morphology of this species resemble those of *C. macrooperculatus*, and for that reason it is regarded as a separate variety" (Karling *loc. cit.*).

18. CHYTRIOMYCES MAMMILIFER Persiel

Arch. Mikrobiol. 36:299, figs. 9, 10. 1960.
PLATE 4, figs. 106-110

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or ovoid, hyaline, diameter 7-35 µm, sessile, sporangial wall smooth. **Rhizoidal system**: Filamentous rhizoids well developed, branched. **Zoospore, discharge**: Operculum present, persistent or not persistent, apical, dome shaped or collapsing after dehiscence, diameter 7-35 µm, discharge pore single; discharge vesicle present; zoospores swarming in vesicle outside sporangium before dispersal; vesicle continuous with sporangium, zoospore discharge as a mass, zoospore motility both intersporangial and extrasporangial. **Zoospore, microscopic**: Zoospores spherical, 3.5-4.5 µm in diameter, single lipid globule hyaline, flagellum 15-18 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, 7-20 µm diameter, hyaline, with a single large refractive globule, thick-walled, bullate or mammilose, bullae hyaline, 3-4 µm in length, 2-3 µm diameter, but smaller in culture. **Ecology and Distribution**: From soil (4000 m), saprophytic on pollen, Persiel (*loc. cit.*), ECUADOR; Johnson (1971:201), ICELAND.

Chytriomyces rhizidiomycis Dogma also has spherical, verrucose to bullate resting spores, which however, contain a compact mass of uniform-sized globules, and a small, eccentric vacuole (Dogma 1983). Regarding spore discharge, Johnson (1971) observed zoospores escaping without swarming in a vesicle.

19. CHYTRIOMYCES MORTIERELLAE Persiel

Arch. Mikrobiol. 36:299, figs. 6, 7. 1960.
PLATE 5, figs. 137-140

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or subspherical, hyaline, diameter 7-40 µm, sessile, sporangial wall smooth. **Rhizoidal system**: Rhizoids filamentous, limited, finely branched. **Zoospore, discharge**: Operculum present, not persistent, apical, subapical, or lateral, dome shaped, (1)3 - 4(7) discharge pores, zoospores discharging through 1-2 exit orifices, remaining opercula often folded into the sporangium after discharge; discharge vesicle present, zoospore discharge as a mass, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 2.5-3.5 µm in diameter, hyaline, with a single, eccentric, 1-1.5 µm diameter lipid globule, flagellum 17 µm long, zoospores elliptical when swimming. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, 4-15 µm, thick-walled, smooth, hyaline. **Ecology and Distribution**: From soil, parasitic on Zygomycetes (*Mortierella* sp., *Zygorhynchus* sp., *Mucor* sp.), causing hypertrophy of infected hyphae, Persiel (*loc. cit.*) AUSTRIA.

20. CHYTRIOMYCES MULTIOPERCULATUS Sparrow and Dogma

Arch. Mikrobiol. 89:193, fig. 5. 1973.
PLATE 5, figs. 141-144

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical, subspherical, ellipsoid, or angular, hyaline, diameter 10-38 µm, height 9.5-40 µm, sessile or having an extramatrical stalk, sporangial wall smooth. **Rhizoidal system**: Apophysis angular, diameter 2-8 µm, filamentous rhizoids limited, sparsely branched. **Zoospore, discharge**: Operculum present, persistent or not persistent, apical, subapical, or lateral, saucer shaped, diameter 2-8 µm, discharge pores three or more (up to 10), discharge papillae present, the apices of which during the later stages of sporangial maturation become circumcisely dehisced but remain attached by a narrow collar of inner wall material to the discharge orifice; discharge vesicle absent, zoospore discharge as an explosive burst, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 3.5-4 µm in diameter, hyaline, with a single large, somewhat basal lipid globule, flagellum 20 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Unknown. **Ecology and Distribution**: From soil, on pollen, Sparrow and Dogma (*loc. cit.*), DOMINICAN REPUBLIC.

This species name is hyphenated as "*multi-operculatus*" in Index of Fungi (4:208).

21. CHYTRIOMYCES NAGATOROENSIS Konno

Sci. Rept. Tokyo Kyoiku Daigaku Sect. B, 14:253, pl. 4, fig. X. 1972.

PLATE 2, figs. 41-44

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium subspherical, hyaline, diameter 8-30 µm, height 7-25 µm, having a persistent zoospore case basally, sessile, sporangial wall smooth. **Rhizoidal system**: Filamentous rhizoids limited, sparsely branched, tufted. **Zoospore, discharge**: Operculum present, not persistent, apical or lateral, saucer shaped, diameter 5-9 µm, discharge pores one or two, discharge papillae present, one or two; discharge vesicle unknown, zoospore discharge unknown, zoospore motility unknown. **Zoospore, microscopic**: Zoospores ovoid, 3.5 µm in diameter, 4-6 µm in length, single lipid globule hyaline, flagellum 20-22 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Spherical to subspherical, 12-13 µm diameter, hyaline, thick-walled, rough. **Ecology and Distribution**: From water, weakly parasitic on *Spirogyra* sp., Konno (*loc. cit.*: Nagatoro, Saimata Prefect), JAPAN.

"This species somewhat resembles *Chytriomyces closterii* Karling (1947), but it differs in several features, such as zoospore dimension, presence of zoospore case, number of papillae, tufted character of the rhizoid, and algal host" Konno (*loc. cit.*).

22. CHYTRIOMYCES PARASITICUS Karling

Bull. Torrey Bot. Club 74:334, figs.1-15. 1947.

PLATE 5, figs. 145-150

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or ovoid, hyaline, diameter 8-30 µm, sessile, sporangial wall smooth. **Rhizoidal system**: Apophysis spherical or angular, diameter 3-6 µm, filamentous rhizoids well developed, finely branched. **Zoospore, discharge**: Operculum present, persistent, apical or subapical, saucer shaped, diameter 4-14 µm, discharge pores one; discharge vesicle present, zoospore discharge as a mass, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 2.5-3 µm in diameter, single lipid globule hyaline, flagellum 14-18 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Unknown. **Ecology and Distribution**: In water, parasitic on *Aphanomyces laevis*, causing local swelling and excessive branching of the mycelium, Karling (*loc. cit.*, New York), US; in soil, parasitic on *Aphanomyces*, Karling (1967:121), NEW ZEALAND.

"The parasite eventually completely destroyed the host. The discharged zoospores were capable of undergoing several intermittent periods of swarming if escape was not at once effected from the confining vesicle" (Karling *loc. cit.*).

23. CHYTRIOMYCES POCULATUS Willoughby and Townley

Trans. Br. Mycol. Soc. 44:183, fig. 3. 1961.

PLATE 6, figs. 169-174

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium ellipsoid, gibbose, or irregular, hyaline, diameter 12-22 μm, height 20-37 μm, having an extramatrical stalk; lower half of sporangial wall ornamented with up to 10 thin, overlapping cupules of wall material. **Rhizoidal system**: Filamentous rhizoids limited, sparsely branched. **Zoospore, discharge**: Operculum present, not persistent, apical, dome-shaped, diameter 5-13.5 μm, discharge pore single; discharge vesicle unknown, zoospore discharge unknown, zoospore motility unknown. **Zoospore, microscopic**: Zoospores spherical, 3.5 μm in diameter, hyaline, with a single, 1.5 μm diameter globule. **Zoospore, ultrastructure**: unknown. **Resting spore**: Elongate, irregular, or gibbose, thick-walled, smooth, hyaline, with 1-2 large globules. **Ecology and Distribution**: From soil, saprophytic on keratin bait, Willoughby and Townley (*loc. cit.*), on keratin, Willoughby (1962:122), UK; from soil, Dogma (1969:352, Michigan), Booth (1971a:939, Oregon), on pollen, Letcher and Powell (2001:1031; 2002:766, Virginia), from water, on pollen, Sparrow and Lange (1977:1887, Michigan), US; from soil, Booth (1969:352, British Columbia), on pollen and keratin, Booth (1971b:955, British Columbia), on pollen, Booth and Barrett (1971:363, East Arctic), Lee (2000:60, Manitoba), CANADA; from soil, Willoughby (1965:103), AUSTRALIA; Czeczuga (1994), POLAND.

Based on actual observations of this organism (Letcher and Powell 2001, 2002), the species is emended as follows: "*Chytriomyces poculatus* Willoughby and Townley emend. Resting spores usually on a short extramatrical stalk 4-6 μm in length by 2-4 μm wide, hyaline, ovoid, 12-24 μm long by 8-16 μm wide, ellipsoid, 9-21 μm long by 7-12 μm wide, surface smooth, with 4-6 overlapping cupules of wall material; containing one or two large, spherical globules 4-8μm in diameter, each globule surrounded by several minute globules; the distal end of the resting sporangium composed of a germ tube and the remnant of the zoospore cyst."

24. CHYTRIOMYCES RETICULATUS Persiel

Arch. Mikrobiol. 36:299, fig. 8. 1960.

PLATE 4, figs. 101-105

Vegetative: Thallus epibiotic or extramatrical. **Reproductive**: Sporangium spherical, hyaline, diameter 8.5-30 μm, sessile, sporangial wall smooth. **Rhizoidal system**: Apophysis subspherical, filamentous rhizoids limited, sparsely branched. **Zoospore, discharge**: Operculum present, persistent or not persistent, apical, saucer shaped, composed of the upper half of the sporangium, first stretching as zoospores emerge, then collapsing after dehiscence, diameter 8-30 μm, discharge pore single; discharge vesicle present, zoospore discharge as a mass, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 2.5-3.5 μm in diameter, single lipid globule hyaline, flagellum 15-18 μm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Spherical, 12-23 μm diameter, hyaline to light yellow, thick-walled with two membranous layers, the outer layer prismatic, the inner layer reticulate, contents granular. **Ecology and Distribution**: From soil, parasitic on Oomycetes (*Pythium proliferum*), Persiel (*loc. cit.*), GERMANY; Willoughby (1965:201), AUSTRALIA.

25. CHYTRIOMYCES RETICULOSPORUS Dogma

Philippine J. Biol. 12:395, figs. 10-21. 1983.

PLATE 5, figs. 126-130

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical, hyaline, diameter 9-22 µm, sessile or having an extramatrical stalk, partially collapsing and cup-like after discharge; sporangial wall smooth. **Rhizoidal system**: A single axis with a distal tuft of sinuous rhizoids with blunt ends. **Zoospore, discharge**: Operculum present, persistent or not persistent, apical or subapical, saucer shaped or collapsing after dehiscence, diameter 8-12 µm; discharge pore single; discharge vesicle absent, zoospore discharge singular, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 2.5-3.5 µm in diameter, single lipid globule hyaline, flagellum 14-17 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Spherical, 8-18 µm diameter, thick-walled, reticulate, golden brown. **Ecology and Distribution**: From cultivated soils, parasitic on *Spizellomyces punctatus* (Koch) Barr, Dogma (*loc. cit.*), PHILIPPINES.

26. CHYTRIOMYCES RHIZIDIOMYCIS Dogma

Philippine J. Biol. 12:386, figs. 1-9. 1983.

PLATE 2, figs. 62-65

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or broadly pyriform, 10-15 µm tall × 8-12 µm broad, spherical or subspherical, diameter 6-14 µm, hyaline, sessile; sporangial wall smooth. **Rhizoidal system**: Rhizoidal axis stiff, filamentous rhizoids finely branched. **Zoospore, discharge**: Operculum present, persistent, apical, saucer shaped, discharge pores one or two, discharge papillae present, one or two, discharge tubes present, one or two; discharge vesicle absent, zoospore discharge as an explosive burst, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 2-2.5 µm in diameter, lipid globules many, hyaline, flagellum 12-14 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Spherical, 7-15 µm thick-walled, bullate or with warts, hyaline. **Ecology and Distribution**: From cultivated soils, parasitic on *Rhizidiomyces bivellatus* Nabel, Dogma (*loc. cit.*), PHILIPPINES, JAPAN.

This species is listed in the Index of Fungi (5:282) as *Chytriomyces rhizidiomycetis*.

27. CHYTRIOMYCES ROTORUAENSIS Karling

Arch. Mikrobiol. 70:269, figs. 1 P-Y; 2 A-S. 1970.

PLATE 5, figs. 151-156

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical, ovoid, pyriform, or variable, hyaline, diameter 10-32 µm, height 18-56 µm, polyhedral to slightly reniform and irregular or clavate when crowded; sporangial wall appendiculate or smooth. **Rhizoidal system**: Filamentous rhizoids well developed, sparsely branched except at extremities, branches extending for distances up to 240 µm. **Zoospore, discharge**: Operculum present, persistent, apical, saucer shaped, diameter 7-10 µm, discharge pores one, with a broad apical or subapical inconspicuous and hardly discernable discharge papilla; discharge vesicle present, zoospore discharge as a mass, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium or separating from sporangium, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 2.8-3.2 µm in diameter, single lipid globule hyaline. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Ovoid, 7-18 µm diameter, or polyhedral when crowded, hyaline, thick-walled, smooth, contents coarsely granular; functioning as a prosporangium in germination. **Ecology and Distribution**: In watered mud samples, saprophytic on chitin, Karling (*loc. cit.*: Rotorua, Aukland Province), NEW ZEALAND.

28. CHYTRIOMYCES SPINOSUS Fay
Mycologia 39:152, figs. 1-39. 1947.
PLATE 3, figs. 84-88

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium pyriform, hyaline, diameter 11-45 µm, height 11-40 µm, sessile; sporangial wall ornamented, with simple or bifurcate spines. **Rhizoidal system**: Rhizoidal axis stalk-like, rarely apophysate, filamentous rhizoids well developed, branched, extending to a distance of 387 µm. **Zoospore, discharge**: Operculum present, persistent, apical, saucer shaped, diameter 2.3-6 µm, discharge pore single; discharge vesicle present, zoospore discharge as a mass, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospore with a single, hyaline lipid globule. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, ovoid, 15-33 µm × 10-33.5 µm, wedge-shaped, 15 µm × 15 µm, rarely spherical, thick-walled, with simple or bifurcate spines, hyaline or slightly yellowish, with a single large globule; functions as a prosporangium in germination. **Ecology and Distribution**: In soil, on cellulose, Fay (*loc. cit.*), from moist soil, on onion skin, Karling (1947), US.

29. CHYTRIOMYCES STELLATUS Karling
Bull. Torrey Bot. Club 74:335. 1947.
PLATE 3, figs. 66-69

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium irregular in shape, spherical, pyriform, or reniform, hyaline, diameter 9-50 µm, height 10-45 µm, sessile; sporangial wall ornamented, with short pegs or with simple spines. **Rhizoidal system**: Apophysis large, diameter up to 18 µm, spherical, fusiform, or angular; filamentous rhizoids well developed, finely branched. **Zoospore, discharge**: Operculum present, apical, saucer shaped, diameter 4-7 µm, discharge pore single, 1-3 or more discharge papillae present; discharge vesicle present, zoospore discharge as a mass, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores ovoid, 3.5-5 µm in diameter, single lipid globule hyaline, flagellum 25-30 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, apophysate, spherical, 9-26 µm or ovoid, 10-14 µm × 15-22 µm, thick-walled, with simple or bifurcate spines, or stellate, sometimes wart-like, or mere undulations of the wall, hyaline, with one large or several smaller refractive globules; functions as a prosporangium in germination. **Ecology and Distribution**: In water and soil, on chitin, Karling (*loc. cit.*, New York, Connecticut), US; BRAZIL.

30. CHYTRIOMYCES SUBURCEOLATUS (Willoughby) Willoughby

Nova Hedwigia 7: 134. 1964.

Chytridium suburceolatum Willoughby, Trans. Brit. Mycol. Soc. 39:132, fig. 4. 1956.

PLATE 4, figs. 115-119

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium wide suburceolate, hyaline, height 4-22 µm, sessile; sporangial wall apiculate or smooth. **Rhizoidal system**: Filamentous rhizoids limited, delicate, single or finely branched. **Zoospore, discharge**: Operculum present, not persistent, apical, saucer shaped, discharge pores one or two; discharge vesicle absent, zoospore discharge as a mass, zoospore motility both intersporangial and extrasporangial. **Zoospore, microscopic**: Zoospores spherical, 2-2.5 µm in diameter, single lipid globule hyaline, flagellum 14 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical or ovoid, thick-walled, smooth, hyaline. **Ecology and Distribution**: From soil, parasitic on other chytrids: *Rhizidium richmondense*, *Rhizophlyctis* sp., *Entophlyctis* sp., Willoughby (*loc. cit.*, 1964), UK; from soil, parasitic on *Rhizophydium sphaerotheca*, Kobayasi and Konno (1970:336), JAPAN.

31. CHYTRIOMYCES TABELLARIAE (C. Schröter) Canter

Trans. Br. Mycol. Soc. 32:16, figs. 1, 2. 1949.

Phlyctidium tabellariae C. Schröter, Neujahrblatt Naturf. Gesell. Zurich, 99: Anmerk. 3, pl. 1, fig. 48. 1897.

PLATE 2, figs. 45-50

Vegetative: Thallus epibiotic, sometimes interbiotic. **Reproductive**: Sporangium ovoid or pyriform, hyaline, diameter 6-15 µm, height 4.3-13 µm, having an extramatrical stalk; sporangial wall smooth. **Rhizoidal system**: Filamentous rhizoids limited, sparsely branched. **Zoospore, discharge**: Operculum present, persistent or not persistent, lateral, saucer shaped, diameter 4.3-8 µm, discharge pore single; discharge vesicle unknown, zoospore discharge unknown. **Zoospore, microscopic**: Zoospores spherical, 3 µm in diameter, single lipid globule hyaline. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, ovoid, 9.9-12 µm broad × 5.7-6 µm high, thick-walled, smooth, hyaline, containing numerous small globules; asexually formed. **Ecology and Distribution**: In water and mud, parasitic on *Tabellaria fenestrata*, Schröter (*loc. cit.*), SWITZERLAND; on *T. floccosa*, *T. fenestrata*, Canter (*loc. cit.*), UK.

32. CHYTRIOMYCES VALLESIACUS Persiel

Arch. Mikrobiol. 36:299, fig. 11. 1960.

PLATE 4, figs. 111-114

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or ovoid, hyaline, diameter 10-30.5 µm, sessile; sporangial wall smooth. **Rhizoidal system**: Filamentous rhizoids well developed, branched. **Zoospore, discharge**: Operculum present, not persistent, lateral, dome shaped, collapsing after dehiscence, diameter 10-30 µm, discharge pore single; discharge vesicle present, zoospore discharge as a mass, zoospores swarming in vesicle outside sporangium before dispersal, vesicle continuous with sporangium, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 3-3.5 µm in diameter, single lipid globule hyaline, flagellum 15-20 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, thick-walled, smooth, hyaline. **Ecology and Distribution**: From soil, saprophytic on pollen, Persiel (*loc. cit.*) AUSTRIA; from soil, saprophytic on pollen, Johnson (1971:200), ICELAND; from soil, parasitic on *Rhizophydium elyensis*, Willoughby (1962:125, as *Chytriomyces* sp. 2), UK; from soil, parasitic on *C. hyalinus* and *R. elyensis*, Willoughby (1965:104), AUSTRALIA.

Persiel recorded vesiculate discharge for this species, whereas both Johnson (1971) and Willoughby (1962, 1965) observed spores being discharged en masse without a vesicle or zoospore swarming. Johnson (1971) also found both apophysate and nonapophysate sporangia.

33. CHYTRIOMYCES VERRUCOSUS Karling

Bull. Torrey Bot. Club 87:327, figs. 1-18. 1960.

PLATE 4, figs. 96-100

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium obpyriform, 20-46 µm high × 14-32 µm broad, subspherical, 24-42 µm, rarely spherical 18-38 µm, urceolate, subclavate, hyaline, usually sessile; sporangial wall smooth. **Rhizoidal system**: Filamentous rhizoids limited and sparse, branched with a bushy appearance, extending to a diameter of 22 µm. **Zoospore, discharge**: Operculum present, persistent, apical, subapical, or lateral, saucer shaped, diameter 8-15 µm, discharge pore single, discharge papillae one; discharge "vesicle" present only as a thin slimy layer, zoospore discharge as a mass, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 2-2.8 µm in diameter, with a single, minute, hyaline lipid globule, flagellum 9-12 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, subspherical or spherical, 14-22 µm diameter, thick-walled, tuberculate or verrucose, light brown. **Ecology and Distribution**: From soil, parasitic on *Rhizophlyctis rosea* (de Bary and Woronin) Johanson, Karling (*loc. cit.*:327, Michigan), US; parasitic on *R. rosea*, Karling (1966:57, Das-Gupta (1982:213), INDIA; parasitic on *R. rosea*, Karling (1968:176), Fiji, OCEANIA.

"*Chytriomyces verrucosus* apparently is a parasite because it was never found growing saprophytically on cellophane, grass leaves, or other cellulosic debris. Whether or not it will attack other chytrids is unknown, as no host range studies were conducted" (Karling *loc. cit.*).

34. CHYTRIOMYCES WILLOUGHBYI Karling

Mycopath. et Mycol. Appl. 36:174, figs. 38-53. 1968.

Chytridium parasiticum Willoughby, Trans. Br. Mycol. Soc. 39:132, figs. 5-7. 1956.

PLATE 6, figs. 157-162

Vegetative: Thallus epibiotic. **Reproductive**: Sporangium spherical or pyriform, diameter 6-22 µm, height 8-27 µm, with a basal cyst 2-3 µm across, sessile or with an extramatrical stalk up to 10 µm long; hyaline, sporangial wall smooth. **Rhizoidal system**: Apophysis minute if present, or absent; filamentous rhizoids limited, varying from an unbranched peg, up to 6 µm long × 1.8-2 µm diameter, or sparsely branched, to a more extensive system. **Zoospore, discharge**: Operculum present, persistent, apical, saucer shaped, discharge pore single; discharge vesicle absent, zoospore discharge as an explosive burst, zoospore motility extrasporangial only. **Zoospore, microscopic**: Zoospores spherical, 3.5-3.8 µm in diameter, single lipid globule hyaline, flagellum 20-24 µm long. **Zoospore, ultrastructure**: Unknown. **Resting spore**: Epibiotic, spherical, 7-17 µm diameter, thick-walled, smooth, hyaline, containing a fairly large central vacuole, contents coarsely granular and dense. **Ecology**

and Distribution: From soil, parasitic on *Rhizidium richmondense*, *Rhizophlyctis* sp., *Entophlyctis* sp., and hyperparasitic on *Chytriomyces suburceolatus* and *Septosperma rhizophydii*, Willoughby (*loc. cit.*), UK; in soil, parasitic on the sporangia and rhizomycelia of *Nowakowskiella* sp., and oogonia and mycelium of *Pythium* sp., Karling (*loc. cit.*: Tokoriki, Fiji Islands; Pitcairn), OCEANIA; parasitic on *Rhizophydium* sp., Sparrow (1965:133, Maui), HAWAII; parasitic on *Rhizophydium stipitatum*(?), Sparrow and Lange (1977:1883, Michigan), US; from soil, parasitic on *Rhizophydium pollinis-pini, R. racemosum, R. elyensis*, and *Mucor* sp., Dogma (1983:400), PHILIPPINES, JAPAN; from soil, parasitic on *Rhizophlyctis* sp., Johnson (1971:201), ICELAND.

TAXONOMIC KEY TO THE SPECIES OF *CHYTRIOMYCES*

Features presented in the taxonomic key are visible with light microscopy, without the use of stains. The features are morphological rather than cytological, ultrastructural, or molecular, as too few species have sufficient data pertinent to these criteria for use in species determination. This will probably be the case for some time to come, as relatively few of the species have been brought into culture. Many species are uncommon to rare, and more than half the species have been observed and reported only upon their discovery. However, other members of the genus such as *C. hyalinus*, *C. annulatus*, and *C. poculatus* exhibit broad to pandemic occurrence, with minimal morphological variation over their wide distribution. Identifying any particular species may require multiple observations over a period of several days to weeks in order to observe mode of spore discharge, zoospore morphology, and resting spores.

KEY TO THE SPECIES OF *CHYTRIOMYCES*

1a. Sporangium tinted golden-orange to red 2
1b. Sporangium hyaline 3

2a. Rhizoidal system apophysate; filamentous rhizoids well developed, extensive, branched .... 4. *C. aureus*
2b. Rhizoidal system apophysate; filamentous rhizoids absent .... 7. *C. cosmaridis*

3a. Sporangia predominantly multioperculate (up to 10) 4
3b. Sporangia predominantly with one operculum (rarely 2-3) 5

4a. Organism parasitic on *Mortierella* sp. .... 19. *C. mortierellae*
4b. Organism saprophytic on cellulose or pollen .... 20. *C. multioperculatus*

5a. Zoospores non-guttulate, containing many small globules 6
5b. Zoospores guttulate, containing a single globule 8

6a. Sporangia spherical or subspherical .... 13. *C. hyalinus* v. *granulatus*
6b. Sporangia appendiculate, ovoid, or broadly pyriform 7

7a. Sporangial wall not ornamented .... 16. *C. macro-operculatus*
7b. Sporangial wall ornamented with numerous long branched hairs .... 17. *C. macro-operculatus* v. *hirsutus*

8a. Sporangium interbiotic 9
8b. Sporangium not interbiotic, but epibiotic 10

9a. Sporangial wall smooth .... 8. *C. elegans*
9b. Sporangial wall ornamented with proximal collar-like undulations at the lower half of the sporangium .... 2. *C. annulatus*

10a. Sporangium angular, appendiculate, or irregular 11
10b. Sporangium globose, subglobose, or pyriform, but not angular 19

11a. Sporangium with an apophysis 12
11b. Sporangium without an apophysis 14

12a. Apophysis globose to subglobose .... 29. *C. stellatus*
12b. Apophysis an inflated tubular structure 13

13a. Zoospores swarming in an exogenous vesicle prior to release . 3. *C. appendiculatus*
13b. Zoospores quiescent in a vesicle, which separates from the sporangium, prior to release .... 15. *C. lucidus*

14a. Sporangium ornamented with overlapping cupules .... 23. *C. poculatus*
14b. Sporangium not ornamented, sporangial wall smooth 15

15a. Organism parasitic 16
15b. Organism saprophytic 18

16a. Parasitic or hyperparasitic on other chytrids .... 30. *C. suburceolatus*
16b. Parasitic on protozoa or algae 17

17a. Parasitic on heliozoan *Raphidiocystis lemani* .... 11. *C. heliozoicola*
17b. Parasitic on diatoms *Tabellaria flocculosa, T. fenestrata*.......... 31. *C. tabellariae*

18a. Rhizoidal axis present, up to 8 μm diameter, with thinner, extensive but sparingly branched rhizoids .... 27. *C. rotoruaensis*
18b. Rhizoidal axis present, but only slightly thicker than remaining rhizoids .... 1. *C. angularis*

19a. Sporangium ornamented with spines, apical teeth, or proximal collar-like undulations 20
19b. Sporangium not ornamented 21

20a. Sporangial wall ornamented with simple or bifurcate spines, sporangium non-apophysate .... 28. *C. spinosus*
20b. Sporangial wall smooth, with 2 sharp teeth at apex, sporangium apophysate or not .... 6. *C. confervae*

21a. Sporangium with discharge papillae or tubes 22
21b. Sporangium without discharge papillae or tubes 24

22a. In discharge, zoospores swarm in an exogenous vesicle .... 9. *C. fructicosus*
22b. In discharge, zoospores not swarming or in an exogenous vesicle 23

23a. Zoospore discharge explosive; zoospores not within a vesicle or mucilage layer .... 26. *C. rhizidiomycis*
23b. Zoospore discharge passive; zoospores ooze out in a mass, enveloped in a thin, slimy layer .... 33. *C. verrucosus*

24a. Sporangium with an apophysis 25
24b. Sporangium without an apophysis 29

25a. Sporangium with 1-20 nodular protuberances extending centripedally (inward) from the sporangial wall .... 12. *C. hyalinus* (syn. *C. nodulatus*)
25b. Sporangium without centripedal nodular protuberances 26

26a. Saprophytic on chitin .... 12. *C. hyalinus*
26b. Parasitic 27

27a. Parasitic on *Aphanomyces* .... 22. *C. parasiticus*
27b. Parasitic on *Pythium* 28

28a. Resting spores spherical, smooth .... 14. *C. laevis*
28b. Resting spores spherical, reticulate .... 24. *C. reticulatus*

29a. Sporangium pyriform 30
29b. Sporangium globose or subglobose 31

30a. Resting spores pyriform, tuberculate .... 10. *C. gilgaiensis*
30b. Resting spores spherical, smooth .... 34. *C. willoughbyi*

31a. Resting spore spherical, with rough wall .... 21. *C. nagatoroensis*
31b. Resting spore spherical, with smooth wall 32

32a. Sporangial discharge passive, spores not in a vesicle .... 25. *C. reticulosporus*
32b. Sporangial discharge with zoospores swarming in a vesicle 33

33a. Rhizoids sparse .... 5. *C. closterii*
33b. Rhizoids well-developed 34

34a. Parasitic on *Aphanomyces* .... 22. *C. parasiticus*
34b. Saprophytic on pollen 35

35a. Resting spore wall smooth .... 32. *C. vallesiacus*
35b. Resting spore wall mammilose or verrucose .... 18. *C. mammilifer*

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(Ingold) Dogma, figs. 23, 27, by Canter, copyright 1961; *C. suburceolatus* (Willoughby) Karling, fig. 118, by Willoughby, copyright 1964; *C. annulatus* Dogma, figs. 163-167, copyright 1969; *C. macro-operculatus* Karling, figs. 120-124, *C. macro-operculatus* v. *hirsutus* Karling, fig. 125, copyright 1981; *C. laevis* Karling, figs. 130-136, copyright 1987.

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PLATE 1

Figs. 1-5. *Chytriomyces hyalinus* Karling (Karling, 1945).
Fig. 1. Young thallus.
Fig. 2. Mature operculate, non-apophysate zoosporangium with coarse, thick-walled rhizoidal axis.
Fig. 3. Emerging zoospores in an exogenous discharge vesicle.
Fig. 4. Mature apophysate resting spore.
Fig. 5. Ovoid, 3-3.5 × 5-5.5 µm zoospore with a hyaline refractive globule.
Figs. 6-11. *Chytriomyces aureus* Karling. Figs. 6, 8-11 after Karling, 1945; fig. 7 after Karling, 1977.
Fig. 6. Young apophysate thallus.
Fig. 7. Apophysate zoosporangium with the large primary nucleus.
Fig. 8. Mature operculate, apophysate zoosporangium.
Fig. 9. Discharged zoosporangium.
Fig. 10. Mature resting spore.
Fig. 11. Ovoid, 3-3.5 × 5 µm zoospore with a golden-red globule.
Figs. 12-15. *Chytriomyces hyalinus* v. *granulatus* Karling (Karling, 1967).
Fig. 12. Young operculate, apophysate thallus.
Fig. 13. Spherical, 5-6 µm diam. zoospore with numerous granules.
Fig. 14. Zoospores swarming in an exogenous discharge vesicle.
Fig. 15. Mature resting spore.
Figs. 16-21. *Chytriomyces nodulatus* Haskins (Haskins, 1946).
Fig. 16. Mature, operculate apophysate thallus.
Figs. 17, 18. Stages of dehiscence of the zoosporangium showing operculum and vesicle.
Fig. 19. Empty zoosporangium with two nodules
Fig. 20. Ovoid, 3-4.5 µm zoospore with a single refractive oil globule near point of attachment of flagellum.
Fig. 21. Resting sporangium.
Figs. 22-28. *Chytriomyces elegans* (Ingold) Dogma. Fig. 22 after Ingold, 1944; figs. 23, 27 after Canter, 1961; figs. 24-26, 28 after Paterson, 1958.
Fig. 22. Young, immature thallus.
Fig. 23. Mature thallus.
Figs. 24-26. Stages in the vesicular discharge of the operculate zoosporangium.
Fig. 27. Mature resting spore; associating bodies with apophyses.
Fig. 28. Spherical, 3.5-4.5 µm zoospores with eccentric oil globule.
Figs. 29-35. *Chytriomyces closterii* Karling (Karling, 1949)
Figs. 29, 30. Two stages of development and maturation of zoosporangium with sparsely branched rhizoidal axis.
Fig. 31. Vesicle discharge of zoospores.
Fig. 32. Zoospores swarming in vesicle prior to release.
Figs. 33. Mature resting spores.
Fig. 34. Germinating resting spore.
Fig. 35. Spherical, 2-2.5 µm diam. zoospores.

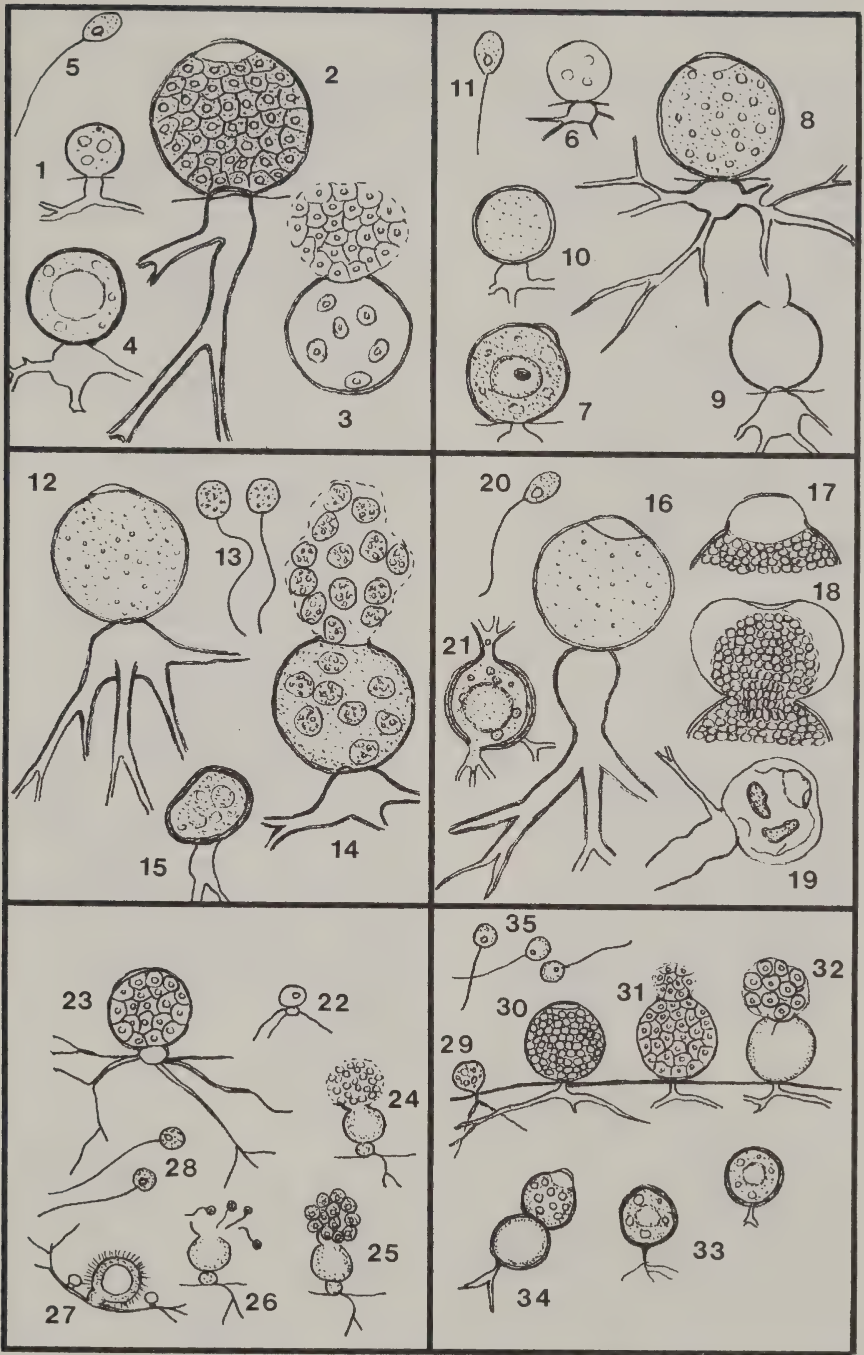
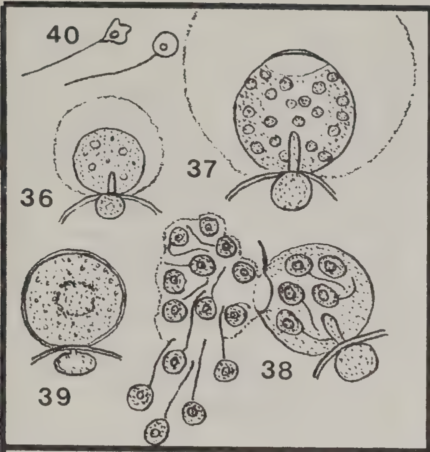
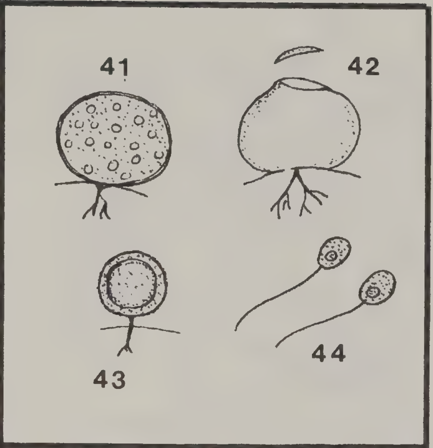
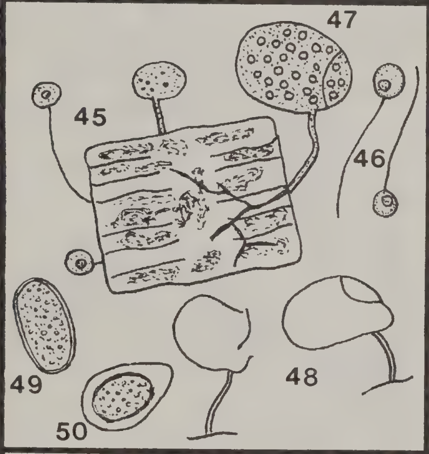


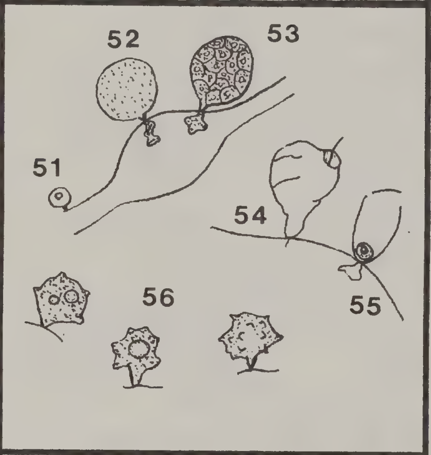
PLATE 2

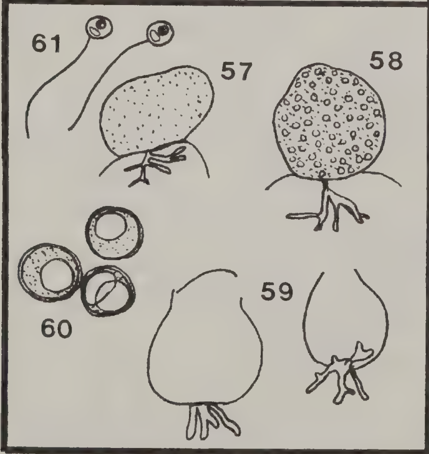
Figs. 36-40. *Chytriomyces cosmaridis* Karling (Karling, 1967).
Figs. 36, 37. Developing sporangia, each surrounded by a halo.
Fig. 38. Zoospores swarming in and escaping from an exogenous discharge vesicle.
Fig. 39. Resting spore.
Fig. 40. Spherical, 2-2.6 µm diam. zoospores with a brilliantly refractive yellow-orange globule.
Figs. 41-44. *Chytriomyces nagatoroensis* Konno (Konno, 1972).
Fig. 41. Developing sporangium.
Fig. 42. Empty sporangium with non-persistent operculum.
Fig. 43. Spherical resting spore with rough wall.
Fig. 44. Ovoid, 3.5 µm diam. zoospores.
Figs. 45-50. *Chytriomyces tabellariae* Canter (Canter, 1949).
Fig. 45. Three stages in early development of thallus on *Tabellaria flocculosa*.
Fig. 46. Spherical, 3 µm diam. zoospore with single refractive globule.
Fig. 47. Mature sporangium.
Fig. 48. Empty sporangia.
Fig. 49. Mature resting spore.
Fig. 50. Resting spore formed by rounding off of protoplasm of the sporangium.
Figs. 51-56. *Chytriomyces gilgaiensis* Willoughby (Willoughby, 1965).
Fig. 51. Encysted zoospore with beak-like protrusion.
Fig. 52. Young thallus.
Fig. 53. Mature thallus with delineated zoospores and lobed haustorium.
Fig. 54. Dehisced sporangium with detached operculum.
Fig. 55. Dehisced sporangium with a single residual zoospore.
Fig. 56. Pyriform, tuberculate resting spores.
Figs. 57-61. *Chytriomyces heliozoicola* Canter (Canter, 1966).
Fig. 57. Immature sporangium.
Fig. 58. Mature sporangium.
Fig. 59. Empty sporangia.
Fig. 60. Resting spores with 1-2 large refractive globules.
Fig. 61. Spherical, 2.5-3 µm diam. zoospores, with an anterior spherical highly refractive globule and a posterior less refractive oval body.
Fig. 62-65. *Chytriomyces rhizidiomycis* Dogma (Dogma, 1983).
Fig. 62. Germling, and immature, mature, and discharged sporangia on *Rhizidiomyces bivellatus*.
Fig. 63. Young zoosporangium with single (a) and two (b) discharge tubes; zoospores escaping through discharge tube (c); two zoospores encysted *in situ* in empty zoosporangium (d).
Fig. 64. Mature resting spores.
Fig. 65. Spherical, 2-2.5 µm diam. zoospores with a central cluster of colorless globules.

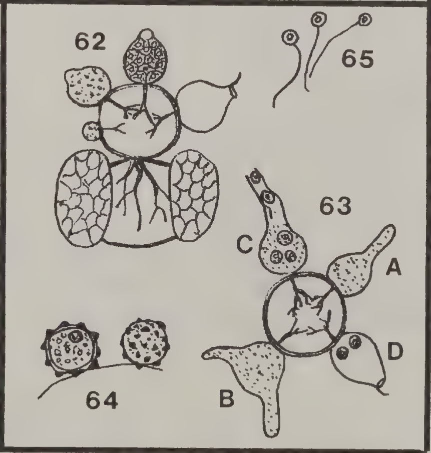











62
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C
A
D
B
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PLATE 3

Figs. 66-69. *Chytriomyces stellatus* Karling, 1947. All figures after Karling, 1977.
Fig. 66. Sparsely spiny apophysate zoosporangium with two exit canals which are filled with hyaline matrix.
Fig. 67. Zoosporangium with two exit papillae.
Fig. 68. Mature, stellate resting spores.
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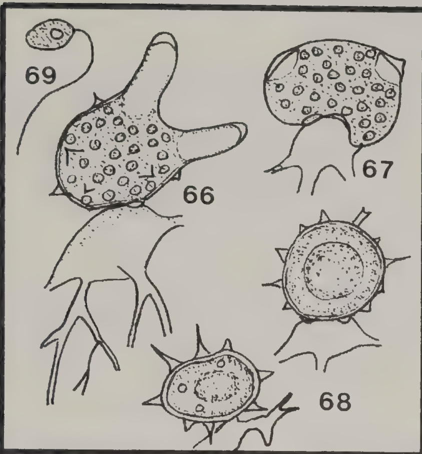
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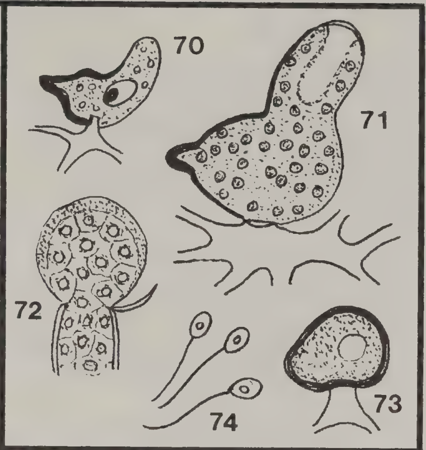
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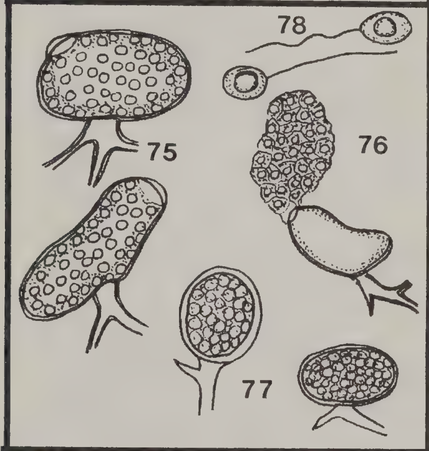
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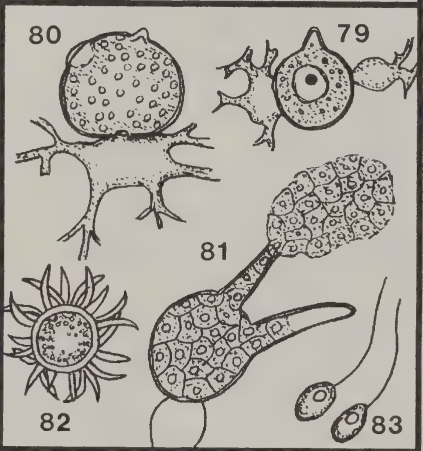
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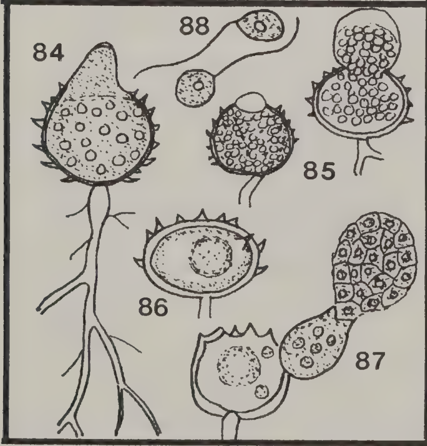
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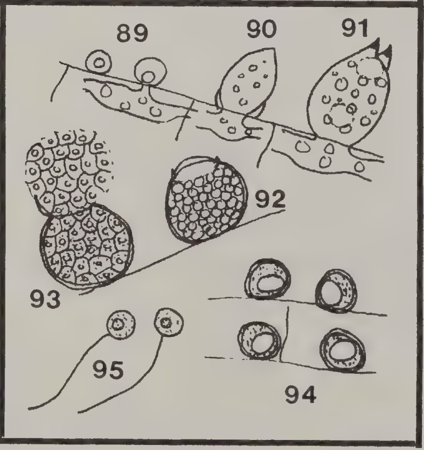
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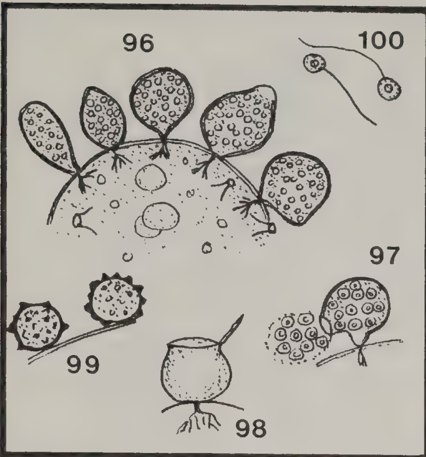
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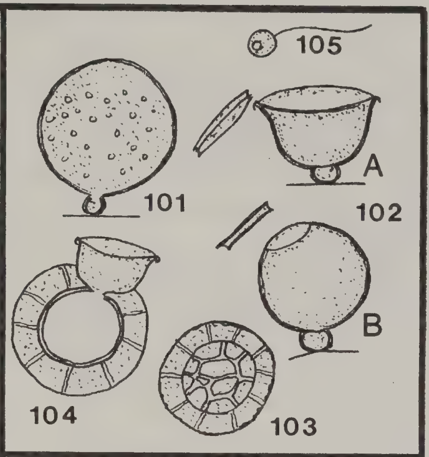
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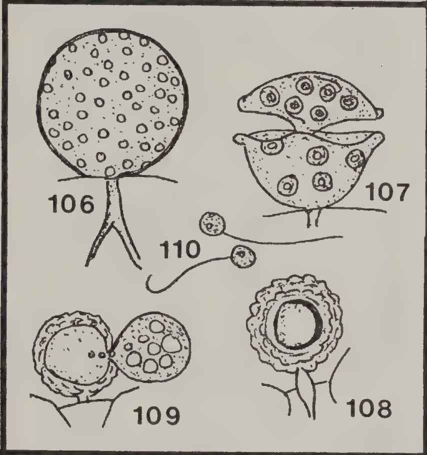
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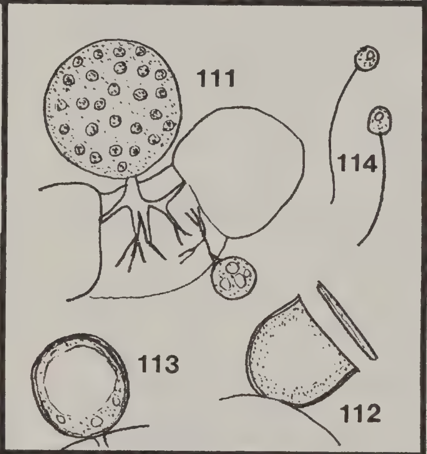
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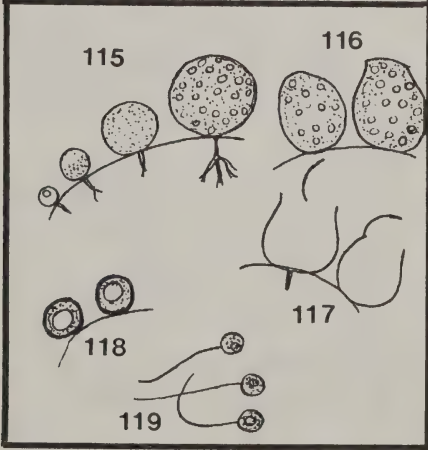
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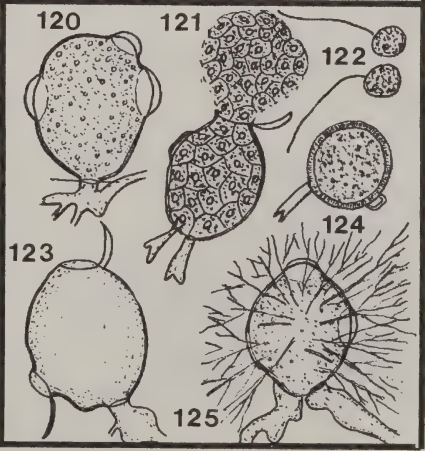
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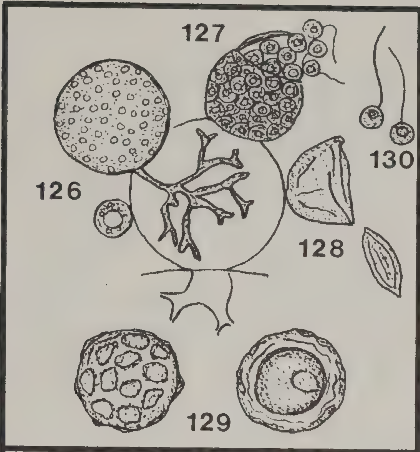

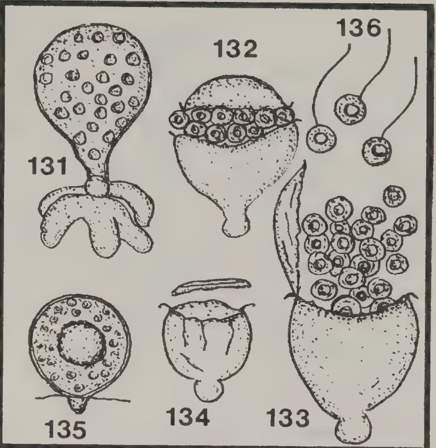

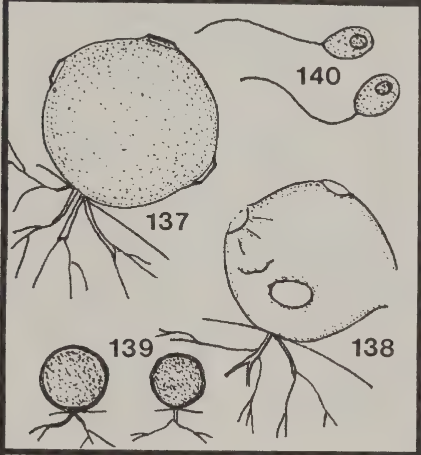

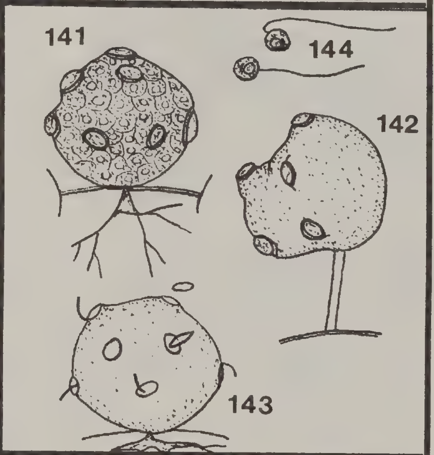

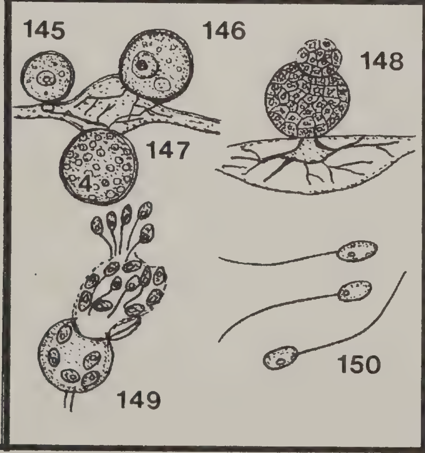

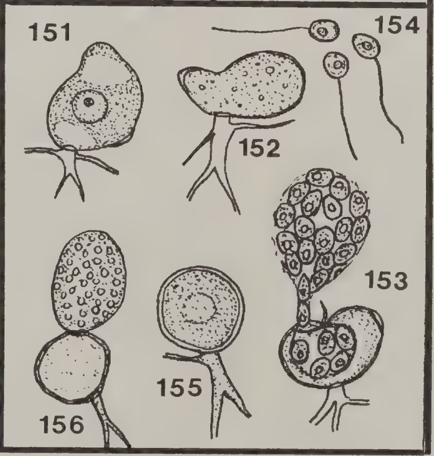

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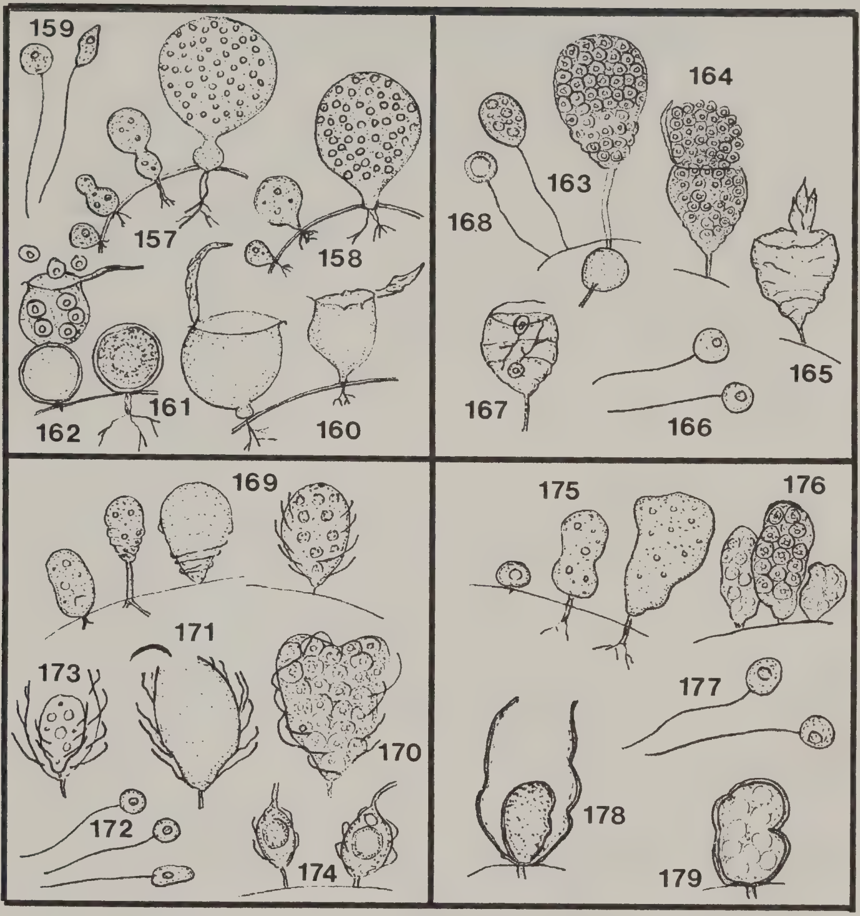

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